INHERITANCE OF STATURE

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INTRODUCTION

   This paper, which it has taken the best part of two years to prepare, has perhaps cost more than the results gained would seem to warrant. Yet so long as the classic topic of heredity of human stature remained insufficiently analyzed, it stood as a constant challenge to the analyst of heredity.   If the work has done nothing more than to prove, what might have been anticipated, that the apparent blending inheritance of stature is due merely to the presence of multiple factors it may be justified.

   The data upon which this paper is based have been gathered by many hands; but those upon which chief reliance is placed were secured, as stated below, by personal studies made on families, with the assistance of ELIZABETH B. MUNCEY, M.D., Miss MARY T. SCUDDER, of Hunting-ton, N. Y., Rev. W. E. DAVENPORT of Brooklyn, N. Y., Prof. W. S. ANDERSON of Lexington, Ky., the Misses VIRGINIA ANDERSON and LUCILE CRUICKSHANK of Lexington, and Dr. J. D. CROOM of Maxton, N. C.   To the host of those who have coöperated in our work, admitting me and my assistants into their homes in Huntington, Patchogue and Brooklyn, L. I., Stamford, Conn., Lexington, Ky., Laurinburg and Maxton, N. C., I would express my thanks for their friendliness.   To my assistant, Miss SCUDDER, is chiefly due the reduction of the vast amount of statistical data accumulated.   Finally this study could hardly have been possible without the organization of the EUGENICS RECORD OFFICE for the foundation and maintenance of which science is in-debted to Mrs. E. H. HARRIMAN.

A. Statement of the problem

I. HISTORICAL

That persons differ in height is one of the most obvious of facts. A moment's consideration suffices to ascribe some of these differences to age (the young are shorter than the mature), others to sex (males are taller than females), and others still to race (the Polish Jews are shorter than the Scotch). There is a wide-spread belief, also, that, within limits, growth in stature may be controlled by conditions of life.

That there are hereditary factors involved in the differences in height of adults follows from the recognition of racial differences, for true racial characters are hereditary. Moreover, this hereditary nature has been popularly long recognized. Thus we are not surprised to find King FRIEDRICH WILHELM I of Prussia, who had an obsession over tall soldiers, planning even to breed them.[1] In the same way CATHERINE DE MEDICI is said to have "caused marriages to be celebrated between male and female dwarfs with the object of producing a dwarf race. Such marriages were, however, uniformly barren" (RISCHBETH and BARRINGTON 1912, p. 358). CHARLES LYELL (1881, I p. 196) writing from France in 1828 says the French troops are

". . . a stunted race. By accurate calculation of the height of men of the levy since the peace, it is found that the mean height of Frenchmen has been diminished several inches by the Revolution and NAPOLEON's wars. These

[1] Details concerning the Prussian Grenadiers are given in the regimental histories. Thus J. BECKER (1885, p. 114) says of the regiment in FRIEDRICH WILHELM's time: "Die Rekrutirung erfolgte nur durch Werbungen in In- und Auslande. Aber die strenge Zucht und die Vorliebe des Königs für 'lange Kerls' veranlasste die Werbe-Offiziere nicht selten zu harten und unerlaubten Mitteln zu greifen.

"Infolgedessen suchte sich ein nicht geringer Teil der heranwachsenden jungen Männer der gewaltsamen Werbung zu entziehen und ging ausser Landes. Um diesem Uebel abzuhelfen, musste eine Zeit lang in Inlande die Werbung eingeschränkt und fast ausschliesslich auf das Ausland übertragen werden."

Rules as to stature of the men were laid down as follows (BECKER 1885, p. 115): "Ein gute Companie muss also beschaffen seyn: Der Flugel soll von 6 Fuss und über 6 Fuss und der erste Zug von 11½ Zoll auch 11 Zoll und der letze Mann in ersten Zuge 11 Zoll wenigsten 4 Stiche haben." (The Zoll was about equal to the British inch; 11 Zoll is evidently an abbreviation for: "5 Fuss 11 Zoll").

It is stated that the King contemplated a system of marrying his tall men to tall women but he died before this system was put into effect and his successor FREDERICK THE GREAT was apparently a sexual invert and wished none of his officers married. Thus, according to PREUSS (1832, I, p. 425-6) he was so successful that on the 5th of April, 1778, at Pasewalk in the famous Baireut Dragoon regiment, of all 74 officers, from the Generallieutnant v. BÜLOW down to the youngest Fähnrich not one was married.

are now the sons of those who were not thought by NAPOLEON strong and tall enough to fight and look well."

Such testimony proves that the inheritableness of stature is popularly recognized.

The method of inheritance of stature has long been a matter of scientific interest. In his *"Natural Inheritance"* GALTON (1889, pp. 77, 78, 83, 84) discussed the data on stature that he had obtained from his Records of Family Faculties and from "special observations." A discussion which has led to such momentous consequences as this of GALTON may well be called a "classic." I cannot forbear reproducing here the introductory words of his chapter which treats of stature.

"The first of these inquiries into the laws of human heredity deals with hereditary stature, which is an excellent subject for statistics. Some of its merits are obvious enough, such as the ease and frequency with which it may be measured, its practical constancy during thirty-five or forty years of middle life, its comparatively small dependence upon differences of bringing up, and its inconsiderable influence on the rate of mortality. Other advantages which are not equally obvious are equally great. One of these is due to the fact that human stature is not a simple element, but a sum of the accumulated lengths or thicknesses of more than a hundred bodily parts, each so distinct from the rest as to have earned a name by which it can be specified. The list includes about fifty separate bones situated in the skull, the spine, the pelvis, the two legs, and the two ankles and feet. The bones in both the two lower limbs have to be counted because the stature depends upon their average length."

This quotation well illustrates the complete change of our point of view in studying heredity since GALTON's day. The great multiplicity of elements entering into stature which was for GALTON a "great advantage" for the study of its heredity may well be considered today so great a disadvantage as to render it impracticable to get at the laws of inheritance of stature from available data on stature. Today we recognize the importance of selecting simple clean-cut characters in studying heredity. We recognize that the key to MENDEL's (1865) success lay in his recognition of this fact. Thus MENDEL says (BATESON 1909, p. 321)

"Some of the characters noted do not permit of a sharp and certain separation, since the difference is of a 'more or less' nature, which is often difficult to define. Such characters could not be utilized for the separate experiments; these could only be applied to characters which stand out clearly and definitely."

However, GALTON exaggerated the number of elements involved in stature, for the length of the vertebræ and intervertebral cartilages depend upon the linear space in the trunk available for their development; they do not determine the length of the trunk.

The method which GALTON used for analyzing the inheritance of this complex character led to important results. It was the thing in GALTON's work that first attracted Professor KARL PEARSON's attention and started him upon the remarkable (even if somewhat misguided) series of papers which rapidly appeared from his pen from 1894 to 1900, and led to the foundation of the "biometric school"—a school whose principles and methods, valuable in certain fields, have shown themselves quite sterile when applied to heredity. GALTON, proceeding by the method of mass statistics, reached the conclusion that children regrèss from mediocrity about one-third as much as the average of the stature of their two parents does. PEARSON (1896, p. 270) concluded, from a much more elaborate analysis, that the regression of sons on fathers is 44 percent. BROWNLEE (1911) has pointed out that the Galtonian result can be interpreted in modern terms if we assume that stature depends upon several independent factors. In 1911 I pointed out that

". . . when the four grandparents are very unlike the adult children will vary greatly in stature, whereas, when the grandparental statures are closely alike, those of the children will be also. When both parents are tall all of the children will tend to be tall; but, on the contrary, if both parents are short some of the children will be short and some tall in ratios varying from 1 : 1 up to 2 : 1" (DAVENPORT 1911).

This conclusion was based on 104 families.

Thus up to the present time no set of original data in stature has been analyzed by modern methods of studying heredity.

II. DEVELOPMENT OF STATURE

The fertilized egg is provided with a mechanism that, in the presence of proper conditions, sets it developing. In the earliest stage—the imbibitory stage—the growth is largely due to a taking in of water. Thus, in the first 14 days of a tadpole's development during which it transforms from a spheroidal egg to an elongated free-swimming tadpole it may gain 22 milligrams of water while it gains only 0.3 milligrams of dry substance; and the proportion of water meantime increases from 56 percent to 96 percent. This is the grand period of growth of the frog (DAVENPORT 1897, p. 75). The grand period of growth in man probably occurs within the first month, perhaps éven before the formation of the gill slits. In later growth the additions of water continue to be great but the additions of dry matter are also considerable and increasing so that, in the frog, the proportion of dry matter increases from 4 percent to 6, 8, and up to 20 percent in the adult frog, and 40

percent or more in adult men. This dry substance is largely "formed substance," secreted by active protoplasm. This stage of laying down of dry matter is known as the second or metabolic stage of growth. Anything which advances the metabolic processes, furthers, anything that interferes with them retards, growth and may affect adult size. In the imbibitory stage growth is, within limits, outside the control of the parent. It is the constitution of the egg that controls the rate of its absorption of water.

The metabolic stage of growth in man may be divided into the uterine and the extra-uterine periods. The first period—that of placental attachment—begins at about the time that the gill clefts first show externally. From this time on new building material is brought to the organism from without. During the first 8 weeks of development the embryo increases from 0.0006 grams to 4 grams or 6,000 times. From 8 weeks to 16 weeks it increases from 4 to 120 grams, or 30 times; from 16 to 24 weeks it increases 5 times; from 24 to 32 weeks, 3 times.

Table I (taken from MARTIN 1914, p. 227) gives the successive lengths of embryos and foetuses of I to 10 months.

TABLE I

Length of human embryo (vertex to heel) at different ages.

	SCHRÖDER (1893, p. 60)	STRATZ (1907)	MICHAELIS (1906)
End of 1st month of gestation	.7— .8 cm	1 cm	—
" " 2nd " " "	.8—2.5 "	4 "	—
" " 3rd " " "	7— 9 "	9 "	—
" " 4th " " "	10— 17 "	16 "	14.9 cm
" " 5th " " "	18— 27 "	25 "	22.3 "
" " 6th " " "	28— 34 "	35 "	29.5 "
" " 7th " " "	35— 38 "	42 "	33.1 "
" " 8th " " "	42.5 "	45 "	39.7 "
" " 9th " " "	46.7 "	48 "	44.3 "
" " 10th " " "	49— 50 "	50 "	—

Obviously the rate and degree of development of the child during the period of placental attachment must depend to a certain extent upon the quality of the blood of the mother. And, indeed, we find great differences in the weight of the child at term, which are determined both by the length and condition of the body, especially the latter. The weight of living children at birth (in Germany) varies from 2500 grams to 5800 grams; the length at birth from 48 cm to 58 cm (DAFFNER 1902, p. 125). There is, even at birth, a slight sexual difference

(on the average) in the same direction as in the adult. There is also a difference in the average length at birth for different peoples correlated to a certain extent with racial differences in adult size. This is shown in table 2. (Data from MARTIN 1914, p. 228.)

TABLE 2

Length at birth of male and female children of various races.

	♂ cm	♀ cm	Author
Anamites	47.4	46.4	MONDIÈRE
Japanese	49.3	47.8	NAGAHAMA
Russian (from Charkow)	49.5	48.3	ORCHANSKY
English	49.6	49.1	ROBERTS
French (from Paris)	49.9	49.2	MIES
Belgian	50.0	49.4	QUETELET
Great Russian	50.5	49.5	TSCHEPOURKOWSKY
South Russian Jews	51.2	50.3	DAFFNER

Of 17 infants, who have been born less than a week, measured by me at the JEWISH MATERNITY HOSPITAL, New York City, the total lengths ran (in cm): 54.5, 52, 50.5, 50.5, 50, 50, 50, 49.5, 49, 49, 49, 49, 48, 48, 48, 47.5, 47. Thus the median stature of this series is 49 cm, slightly less than the average found by DAFFNER for South Russian Jews.

With birth begins the second metabolic stage of growth—that of the post-foetal life. The increases in the first few months of post-foetal life are very great and the sexual differences become strongly expressed by the more rapid growth in length of the male. This is shown in table 3, taken from MARTIN (1914, p. 228). For the whole post-foetal period we have a curve of growth such as is given in figure 1.

TABLE 3

Body length of Russian children (from TSCHEPOURKOWSKY).

	♂ cm	♀ cm
1st week	50.5	49.5
1st month	51.3	50.5
2nd "	53.5	52.8
3rd "	57.0	53.9
4th "	58.7	55.4

This shows that the yearly absolute increments tend in boys to fall off somewhat toward the end of the second year and still more toward the end of the sixth (or seventh) year. Continuing to slow up during
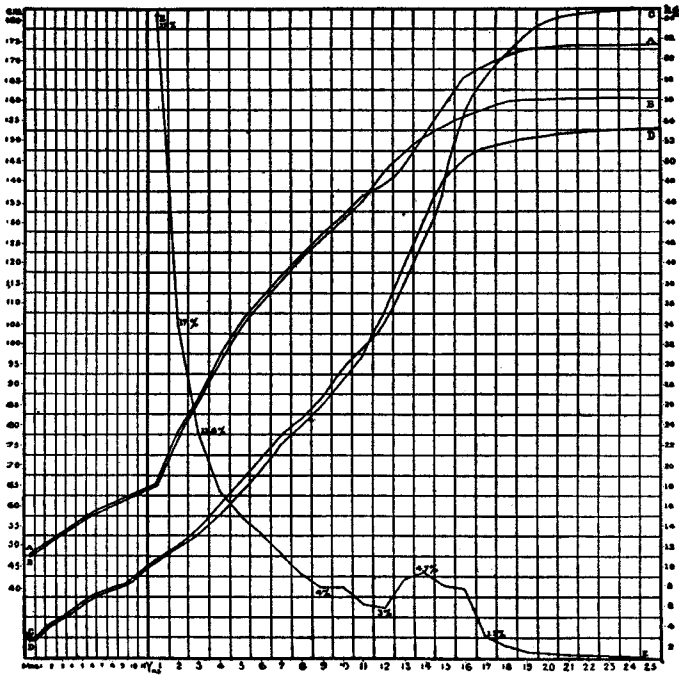
FIGURE I.—Curves of development, ages being laid off as abcissae and absolute stature (in centimeters) or weight (in kilograms) being laid off as ordinates. The first 12 months of life are on a different scale ($\times$ 6) from subsequent years. Curve AA is that of stature for boys. Curve BB is that of stature for girls. Curve CC is that of weight for boys. Curve DD is that of weight for girls. Curve EE shows for boys the percentage of growth in stature made in the successive years and is especially adapted to showing the periods of retardation and acceleration in growth. From J. W. SEAVER, "*Anthropometry and Physical Examination.*"

the ninth year, boys fall in stature behind girls, but at the end of the eleventh or twelfth year the increments increase and continue until the end of the fourteenth year (in the United States until the end of the fifteenth year). This is the period of rapid adolescent growth. The same thing appears in the curve for girls except that there is no slowing up of increments in the ninth year but they go right on holding their own or increasing slightly until the end of the thirteenth year. Consequently they come to exceed the male statures for the ages from 10 (or 11) up to 14 years. After 14, menstruation having begun to set in, the increments of growth fall off markedly, permitting the boys to pass in stature their sisters of the same age.

After the full onset of puberty, which occurs about a year later in boys than in girls, the curve of increments falls rapidly until in girls

at 18 and boys at 20 growth is practically finished. From 20 to 25 years there is, on the average, an increase in stature among males of from 2 to 5 mm, in part depending on race.

The age at which adult stature is achieved varies in individuals. Indeed, as Boas (1898, p. 1541) has pointed out, variability in stature is exceptionally high between the ages of 13 and 17. Detlefsen (1914, p. 120) finds a slight increase in variability of weight of rabbits at 1 year. Pearl and Surface (1915) have discovered that the height of the corn plant is more variable at the onset of tasseling. I give an example of such extreme variability in man. Mrs. V., of Huntington, whose stature is 169.5 cm (67.5 inches) stated that she had gained her full height at the age of 13 years. By her husband (165 cm high) she had a daughter whose stature at 17 years was 168 cm, another 163 cm tall at 20 years, and a third whose *stature at 11 years was 160 cm,* or only about 3 to 8 cm short of her probable maximum, though, on the average, an increase of 25 cm to the stature at 11 years is expected.

An examination of the curve of growth brings out this important point that the growth processes which are fairly progressive up to about 14 years, begin to be damped off after that period. Were the average rate of growth of the female between the ages of 8 and 14 maintained up to the age of 25 years, the average woman at that age would be over 210 cm or 82½ inches or nearly 7 feet tall. The reason why we do not reach such a stature is because our growth is damped off; and the principal damping off occurs as the germ glands ripen. Variations in adult stature may conceivably result from an acceleration or retardation in this damping off process.

For, there is a clear correlation, though not perfect, between the average time of onset of puberty and the average age of slowing up of growth and it is probable that the former controls the latter. If one reason why one person is tall and another short is that in the first the onset of puberty is delayed, in the second accelerated, this might come out by asking a number of tall and short correspondents about the age of onset of puberty in their cases, and this I did. But, apparently, data of onset of puberty is a matter of which record is rarely made; so I did not get much satisfaction. In one case, a man of 6 feet 4 inches thought that the onset of puberty was somewhat later than in his brothers. Another, 6 feet tall, thinks that the age of onset of puberty was the same as his shorter brothers, but he has had temporarily a slightly enlarged thyroid. Another (6 ft. 3 in.) says "from childhood

I was always very tall for my age." Equally unsatisfactory are the returns from the under-sized people. One man (J. N. C.) of 5 ft. 7½ in. says he stopped growing when he was about 15 or 16 years of age. Another, much under size, says that having been brought up in the city he had little opportunity for active exercise; but just prior to maturity (at 11 years) he was on his cousin's ranch and grew 7 inches in one year and then he stopped growing almost completely.

There is, on the other hand, abundant evidence that many dwarfs are such because they ceased to grow at an early age and have merely retained their youthful size. In conversation with dwarfs I have secured the following data: The dwarf, JOSEPH ZAINE, was of normal size until 7 years of age when he stopped growing. His stature is now 117 cm which is about that of a boy of 7 years. The dwarf, HELEN L. HASKILL, was of normal weight at birth and developed slowly. At 16 months she weighed about 7.3 kilograms (normal is 8.8 kg). At 12 years she weighed only 10 kg (normal about 30 kg); at 20 she started to grow and at the same time she matured. ANNIE NELSON (Mrs. GEORGE LAIBLE), ateliotic, stopped growing at 7 years and has done little growing since. In addition, many midgets are very small at birth and grow slowly (fig. 19).

III. RACIAL DIFFERENCES IN STATURE

As is well known the average stature attained by men of different races is very varied. It runs from 138 cm (4 ft. 6 in.) in the case of the Negrillo Akkas to 179 cm (5 ft. 10 in.) in the case of the Scots of Galloway. Says DENIKER (1906, p. 30) "the true home of the low stature populations is in Indo-China, Japan and the Malay Archipelago" (under 158 cm or 62 inches). The tall races of the globe are the Northwestern Europeans, Polynesians, North American Indians and the Negroes of Sudan and adjacent parts of Africa (over 173 cm or 68 inches). The existence of these racial differences of stature is the best evidence that stature depends upon inheritable factors.

IV. SEXUAL DIFFERENCES IN STATURE

In all races of mankind adult men are taller than women and the modal difference is taken as 12 centimeters or 5 inches. This absolute difference between the sexes holds pretty closely for all races, but it is probably still more accurate to state that the male stature is to the female as 100 is to 92, at least for the taller races. This is the difference that GALTON (1889, p. 61) adopts. This difference in the sexes is one that

is characteristic of mammals in general. It is associated with the earlier cessation of growth in the female and with the earlier onset of maturity at which epoch growth is nearly finished.

V. CONTROL OF STATURE BY EXTERNAL AGENTS (NUTRITION)

Variations dependent on this cause are due less to quantity than to quality of ingested food. The studies of OSBORNE and MENDEL (1914) are of great importance here. They find that if rats be fed all they will eat of maize deprived of an amido-acid and tryptophan they will cease to grow and will fall far behind their fellows who have received these materials. It is important to note, however, that if the tryptophan be restored, even after the lapse of months, the little rats start again to grow and eventually catch up with their fellows. That is, the specific growth factor works itself out when it is given a chance despite the prolonged continuation of unfavorable conditions. This is important as indicating the improbability that, in this country at least (and with the class of people with which our statistics have to do) insufficient or improper food counts for much in determining eventual height; temporary starvation has little or no effect on the end result. So, likewise, overfeeding, however much it may affect weight, has probably little effect on adult stature; though it may hasten growth and thus enable a man to reach precociously his predestined stature. The comparative lack of dependence of growth on quantity of food is shown by the fact that a bantam chick which is fed heavily never develops into anything but a bantam fowl.

VI. CONTROL OF GROWTH BY INTERNAL SECRETION

If food conditions have only limited and special relations to growth this is not at all the case with internal conditions. We now know that variation in the amount of the secretions thrown into the body by various ductless glands have important relations to growth. Let us consider some of this knowledge.

Gonads. We have seen how, with the ripening of the germ glands, the rate of growth is temporarily accelerated and then soon brought to a full stop. This intimate correlation between changes in the rate of growth and changes in the functioning of the germ gland suggests that the secretions of the latter influence the former. And it has been suggested that the reason why women are, as a sex, shorter than men, is because maturity (and with it cessation of growth) occurs earlier in women than in men. It is further the result of experience that eunuchs

who are so made before adolescence, tend to grow tall, "leggy" (TANDLER and GROSS 1909), especially in the tibia (PONCET 1903), while at the same time they tend to become obese. Similarly, castrated bulls, or "steers," and cocks, "capons," tend to continue growth beyond ordinary limits. Thus the internal secretions of the gonads play a rôle in limiting growth.

Thyroid. This gland has long been known to exert a control over growth. Insufficient thyroid secretion in children results in undergrowth (cretinism)—a result which may be prevented in some degree if extract of thyroid be given at an early age. I add (table 4) measurements of the stature of a few cretins at Randall's Island, New York City.

TABLE 4

Stature of cretins in comparison with normal of each sex.

Males

No. and age	(17) 37 yrs	(18) 53 yrs	Normal ♂
Stature	109 cm	129 cm	173 cm

Females

No. and age	(8) 21 yrs	(7) 23 yrs	(3) 27 yrs	Normal ♀
Stature	134 cm	125 cm	133 cm	160 cm

The foregoing measurements show a reduction from normal stature in cretins of 37 and 25 percent in the males and of 22, 17, and 16 percent in the females. One may say that cretins fail of realizing about one-fifth of their normal growth.

The *pituitary body* at the base of the brain yields secretions to the blood stream that help control growth and development. When the pituitary body during the growth period secretes in excess, overgrowth occurs "resulting in gigantism when the process antedates ossification of the epiphyses" (CUSHING 1912, p. 25); if it secretes too little (during childhood) there is "skeletal undergrowth, incomplete sexual adolescence and changes in the other ductless glands" (CUSHING 1911, p. 37).

The *pineal body* has a close correlation with growth and the disease of this body in young subjects is associated with increased growth (McCORD 1914; DOCK 1915).

Of the activity of these "ductless glands" there are, of course, all degrees and the suggestion readily occurs that one reason why growth proceeds faster and goes further in one person than another is because

thyroid, pituitary or pineal gland secretes more or during a longer period.

Variations in the secretion of the glands mentioned are very common and, no doubt, hereditary, i. e., racial. The quantity of the secretion varies from time to time with internal conditions and it is affected by severe general diseases such as tuberculosis or syphilis and even scarlet fever, measles, whooping cough and acute articular rheumatism (see DALE 1915). This is the significance of the widespread belief that a given short stature has resulted from a severe infantile disease.

Since growth is so dependent upon secretions that, in turn, are modified by numerous common accidents, one might feel justified in doubting if any inheritance of stature can be traced. On the other hand, it must not be forgotten, first, that the degree to which the functioning of a gland is disturbed by bad conditions is not independent of hereditary factors and also the variations in the ordinary functioning of a gland are determined largely by such factors. Moreover, it appears to be true that the minor disfunctionings of the endocrine glands are unable to prevent the eventual working out of the organism's hereditary growth potentialities. OSBORNE and MENDEL (1914, p. 103) conclude from their experiments that the capacity to grow is not "lost with age, independently of whether it has or has not functioned during the period usually associated with increase in size." Also, the disfunctioning is more apt to exaggerate than to oppose hereditary tendencies. Thus, it is said that "acromegaly affects especially people of large size" (DOCK 1915). In view of all these considerations we have to conclude that the factor of heredity cannot be neglected; it remains to be seen in how far it is determinative.

VII. RELATIVE IMPORTANCE OF CONSTITUTIONAL AND ENVIRONMENTAL FACTORS

There is a strong tendency with certain persons to ascribe idiosyncrasies in stature almost wholly to peculiarities of conditions of development. RIPLEY (1900, p. 85) has fallen into this error in trying to account for the shorter stature of the interior (as contrasted with coastal) cantons of Finisterre on the ground of inferior food supply— forgetting for the moment the difference of blood. Similarly the superior stature of the residents of the state of Kentucky has been ascribed to lime in the soil, and I entertained that hypothesis myself before going to Lexington. The real reason why the people of Lexington, Kentucky, run tall is because they have a large proportion of Scotch

blood, as they readily admit. One can test this conclusion by going to Scotland County, North Carolina. This is on the coastal plain where there is practically no lime. Here, at places like (Mac) Laurenburg, (Mac) Queensdale and Maxton (Mac's town) a nearly pure Scotch population is found—descendants of the Cape Fear River immigrants—and they are even taller than the people of Lexington, Kentucky. This experience points strongly to the conclusion that internal constitutional factors are more important than the ordinary environmental differences.

B. INHERITANCE OF TOTAL STATURE

I. STATEMENT OF THE PROBLEM

Although stature is a graduated trait, due to a multiplicity of more or less independently varying elements, yet, owing to the presence of *general developmental factors,* it is possible profitably to consider the relation between the stature of persons in successive generations. Such inquiry will be made both by the mass statistical method of biometry and by the analytical specific-mating method of modern genetics. Our problem is this: By the use of these methods can we detect the presence of specific growth-modifying factors and what is their hereditary behavior?

II. MATERIAL AND METHODS

The material for this study has been drawn in large part from the statements of volunteers made on the "Record of Family Traits" schedules of the EUGENICS RECORD OFFICE and others. Especially must be mentioned a selected list of names and addresses of very tall and very short persons kindly sent us by Mr. ARTHUR HUNTER of New York. To the persons named was sent a special schedule asking for exact height of close relatives, including grandparents, and many data were returned. The quality of these data is doubtless about the same as those of GALTON; the replies on the special schedule are probably more carefully given than on the "Record of Family Traits" schedules. However, these data have their limitations. It is probable that in some cases the height given is merely an estimate; and it is not always clear whether the record is made with the shoes on or off. The presence of special disturbing conditions, such as a slight scoliosis, although sometimes recorded may not always be so. In a word, the material, although valuable because of its extent (it comprises 2354 children of parents whose height is recorded), is not all scientifically precise.

A second lot of data was secured by myself and by my trained assist-

ant, ELIZABETH B. MUNCEY, M.D., using the "Seaver rod," much employed for anthropometric purposes. Further details concerning this material and how it was secured are given below (page 349) where we deal with analytical studies on inheritance of stature.

In studying this mass of data it has been found convenient first to substitute for the actual measurements deviations from the mean of the sex. This mean is taken once for all throughout this paper as: *68 inches (173 cm) for the male; 63 inches (160 cm) for the female.* All statures in this chapter are expressed (to the nearest inch) in terms of deviations from these averages. By this method the sexual differences, which are so important in absolute measurements, may be disregarded.

Also, it is convenient to group the parents into fairly large classes so as to get a significantly great number of offspring to a class. The following classes were adopted:

Very tall, $+5$ inches and taller   Very short, -5 inches and shorter
Tall, $+4, +3, +2$ inches   Short, $-4, -3, -2$ inches
Medium, $+1, 0, -1$ inches

All statures are placed in one of these 5 categories: and the terms as used always have the definitions given above. Statures are always assigned to the nearest whole inch. The English system of long measure was adopted because it is in common use in this country and because most of the original data were recorded in this system. However, the measurements made by my assistant and myself were in centimeters and fractions and had to be transmuted for the purpose of this chapter into their English equivalents.

III. MASS STUDIES ON INHERITANCE OF STATURE

1. *Statement of the problem*

Recognizing that there are "growth-as-a-whole" factors, we have to inquire into their nature. It is expected that a comparison of the stature (especially the variability of stature) of the offspring of parents of different statures will throw some light on this subject. For the more variable the progeny of a given class of matings the more numerous the hidden recessive (hypostatic) factors in the germ cells of the parents; the less variable the progeny the fewer the hidden recessive factors. The stature of the parents that have the least variable progeny is probably determined by the presence and activity of the greatest number of *recessive* (or negative) factors, or the absence of the greatest number of positive factors.

2. *Results*

In our mass studies we have, in the usual biometric fashion, grouped all parental combinations into the same class (without considering the gametic constitution of the parents) and then compared the arrays of children from such phenotypically classified parents. The results are given in table 5. They are not without interest in that they show the distribution of filial statures derived from various matings.

Table 5 shows clearly that the distributions of filial statures differ greatly in the different classes of matings and the averages of the children differ in the same sense as the parents. This is the usual result in graduated characters. Thus when both parents are *very tall* all the children are above the average in stature.[2] When both parents are *very short* all children, except 1 medium, are short or very short. If both parents are of medium stature the modal stature of the children is the average stature of the population. Of the mating *very short* by *very tall* all offspring (6) are within an inch and a half of the average for the population.

The distribution of the offspring of *tall* (or *very tall*) mated to *tall* (or *very tall*) is characterized by relatively low variability (index of variability, $\sigma = 2.26 \pm .05$). The matings *very short* $\times$ *short* and *short* $\times$ *very short* give a somewhat more variable offspring (index, $\sigma = 2.56 \pm .11$); but the matings *very tall* $\times$ *short* (index, $\sigma = 2.74 \pm .17$) and *very short* $\times$ *tall* (index, $\sigma = 3.22 \pm .22$) and their reciprocals give the highest variability of all.[3]

The foregoing results are shown graphically in the frequency polygons of figure 2. The fact that the offspring of matings of short persons are more variable than the offspring of tall persons suggests that there are one or more general growth-shortening factors that are dominant over their absence.

3. *Selective mating of stature*

As table 5, second column, giving the number of each class of matings, shows, the different classes are not equally common. No matings of very tall men and very short women and only 1 case of the reciprocal were found in our records of 879 matings. On the other hand, there

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[2] There is 1 exception in 106 children—the case of a man who is 5 feet 6 inches, or 2 inches below the average. His sister writes: "My brother had a very severe illness when about a year old; we think that is the reason he did not grow as tall as the rest of us." This case is omitted in calculating the filial variability.

[3] There are not enough offspring of the mating *very short* $\times$ *very tall* to calculate a significant variability.

TABLE 5

Distribution of filial statures from the given matings, in departures, in inches, from the mean.

Parental mating	Number of matings	F Average deviation of stature from mean	M Average deviation of stature from mean	+12	+11	+10	+9	+8	+7	+6	+5	+4	+3	+2	+1	0	−1	−2	−3	−4	−5	−6	−7	−8	−9	−10	−11	−12	Total	Average	σ
1. Very tall × very tall	23	5.782	5.826	1	1	2	10	11	26	12	16	12	8	5	1	[1]													105	6.076	2.380 ± .11
2. Very tall × tall	5	5.848	3.333				1	11	19	21	18	22	17	9	9	2	2	1	2										134	4.493	2.399 ± .10
3. Tall × very tall	71	3.181	5.746	1	1	0	8	21	30	40	45	47	31	27	6	6													263	4.863	2.372 ± .07
4. Tall × tall	91	2.955	2.912				2	11	27	31	53	62	90	53	35	19	8	0	1										392	3.556	2.106 ± .05
5. Very tall × medium	21	5.857	.3809				1	3	4	13	7	14	17	10	8	9													86	3.593	2.201 ± .11
6. Medium × very tall	34	.176	5.764			3	5	5	6	13	22	22	24	21	10	13	3	1	0	2	1	2	0	1					154	3.305	3.149 ± .12
7. Tall × medium	86	2.872	.1864					4	9	16	21	44	48	59	44	34	23	11	6	9	1								329	2.049	2.541 ± .07
8. Medium × tall	81	.123	2.851				1	3	6	14	13	37	45	38	34	30	20	7	6	2	1	0	2	2	0	1			262	1.954	2.806 ± .08
9. Medium × medium	96	—.0625	.125						1	3	1	26	26	42	58	73	41	31	21	8	4	3							338	0.349	2.247 ± .06
10. Very tall × short	5	5.6	—2.6						1	1	0	1	7	2	7	1	2	1	1	0	1								25	1.480	2.558 ± .24
11. Short × very tall	8	—2.5	5.75						2	1	3	2	2	5	4	5	4	3	0	2									33	1.364	2.859 ± .24
12. Tall × short	33	2.848	—2.636					1	1	3	7	13	12	15	31	19	10	13	10	4	1	0	0	2					142	0.803	2.759 ± .11
13. Short × tall	55	—2.709	2.691						2	1	8	10	17	16	18	27	27	15	15	4	1	2							163	0.405	2.599 ± .10
14. Medium × short	45	— .2045	—2.711							2	3	3	6	12	22	22	27	24	16	4	4	0	2	1					148	—0.527	2.426 ± .10
15. Short × medium	86	—2.709	— .18604								5	7	23	36	30	46	35	40	23	14	9	2	1						271	—0.295	2.235 ± .06
16. Short × short	52	—2.769	—2.7307						1	0	1	0	4	8	18	17	34	27	21	7	5	9	0	1					153	—1.359	2.334 ± .09
17. Very tall × very short	0																											0		
18. Very short × very tall	1	—6.0	6.0												4	2													6	+0.667	0.472 ± .09
19. Tall × very short	3	2.333	—5.0								1	1	0	1	1	2	3	1	0	0	2								12	—0.250	2.919 ± .40
20. Very short × tall	1	—5.636	2.454								1	1	3	2	2	4	3	4	5	3	2	3	1	1					35	—1.629	3.244 ± .23
21. Medium × very short	8	— .25	—5.75									1	1	3	1	5	7	4	2	1	4	2							31	—1.387	2.590 ± .22
22. Very short × medium	23	—6.434	— .5652									1	2	5	2	11	10	11	14	7	13	8	2	1					87	—2.471	2.608 ± .13
23. Short × very short	13	—2.538	—5.916											2	2	2	3	5	7	12	5	6	2						46	—3.283	2.243 ± .16
24. Very short × short	22	—6.00	—3.095									1	2	4	2	1	4	11	16	10	6	2	4	2	1	0	0	1	65	—2.815	2.754 ± .16
25. Very short × very short	6	—6.833	—6.00													1	0	0	3	3	2	4	2	2	0	0	1		18	—5.889	2.404 ± .27

Total 3298

are 96 matings of the class, medium × medium. A part of this discrepancy is, of course, due to the greater relative frequency of persons of medium than of extreme stature. But an important part is a consequence of selective mating. Very tall men rarely select very short women not merely because very short women are relatively uncommon (table 5 includes 30 very short mothers) but because such women are selected against by very tall men and are chosen by medium to very short men.

The extent of preference or distaste is indicated in table A by the "preference factor" (pref. fact.) which is the factor by which the "standard proportion" must be multiplied to give the actual relative frequence (rel. freq.) of the mating. For example, 8 out of 50 mothers are very tall; if very tall men married at random 8 out of 50 choices should be of very tall women; actually 23 out of 50 are of very tall women. Since $23 = 8 \times 2.875$, 2.9 is the "preference factor."

Conclusion: Very tall men tend to marry a greatly disproportionate number of very tall women (and few or no very short ones); also tall men marry a disproportionate number of very tall women; medium men tend to marry women of the various statures about in their proportion in the whole population. Short men tend to marry short women and few very tall ones. Very short men marry an excess of short and very short women and relatively few very tall and tall ones. In a word, persons of similar stature tend to marry each other; and extremes are more particular in this respect than those of medium stature.

IV. FAMILY STUDIES

1. *Statement of problem*

In most studies on heredity of stature only parents and children are considered. The parents are considered as a mass and the children as a mass, and the relation of the stature of particular fraternities of children to their particular parents is neglected. Modern genetics has demonstrated the inadequacy, for the study of heredity, of any other method than that of the study of individual families and the consideration of at least 3 generations. The last desideratum is, however, rarely attainable. In a rather extensive experience in the measurement of families I have not once been able to measure two or more grown children, both parents and all four grandparents. Moreover, on account of the shrinking of grandparents in stature, even such complete sets of family statures would not be wholly satisfactory. Not until statures are generally accurately made and recorded for different ages will it become possible—a generation later—to make the desired sort of studies. Meanwhile we shall

TABLE A

Showing the relative frequency and preference factor of each class of statures to which belong the brides (mothers) selected by grooms (fathers) of each class of statures.

| | | Grooms (fathers) | | Brides (mothers) | | | | | | | | | | | | | | |
Class	Standard proportion	Class	Stand. prop.	Very tall 8			Tall 14			Medium 18			Short 9			Very short 2		
				Freq.	Rel. freq.	Pref. fact.	Freq.	Rel. freq.	Pref. fact.	Freq.	Rel. freq.	Pref. fact.	Freq.	Rel. freq.	Pref. fact.	Freq.	Rel. freq.	Pref. fact.
		Very tall	3	23	8.4	2.9	5	1.0	0.3	21	3.4	1.1	5	1.6	0.5	0	0	0
		Tall	16	71	25.9	1.6	91	18.8	1.2	86	13.8	.9	33	10.5	.7	3	5.0	0.3
		Medium	15	34	12.4	.8	81	16.7	1.1	96	15.4	1.0	45	14.3	.9	8	13.3	0.9
		Short	12	8	2.9	.2	55	11.3	.9	86	13.8	1.2	52	16.6	1.4	13	21.7	1.8
		Very short	4	1	.4	1.0	11	2.3	.6	23	3.7	0.9	22	7.0	1.8	6	10.0	2.5
		Totals	137	137	50.0		243	50.1		312	50.1		157	50.0		30	50.0	
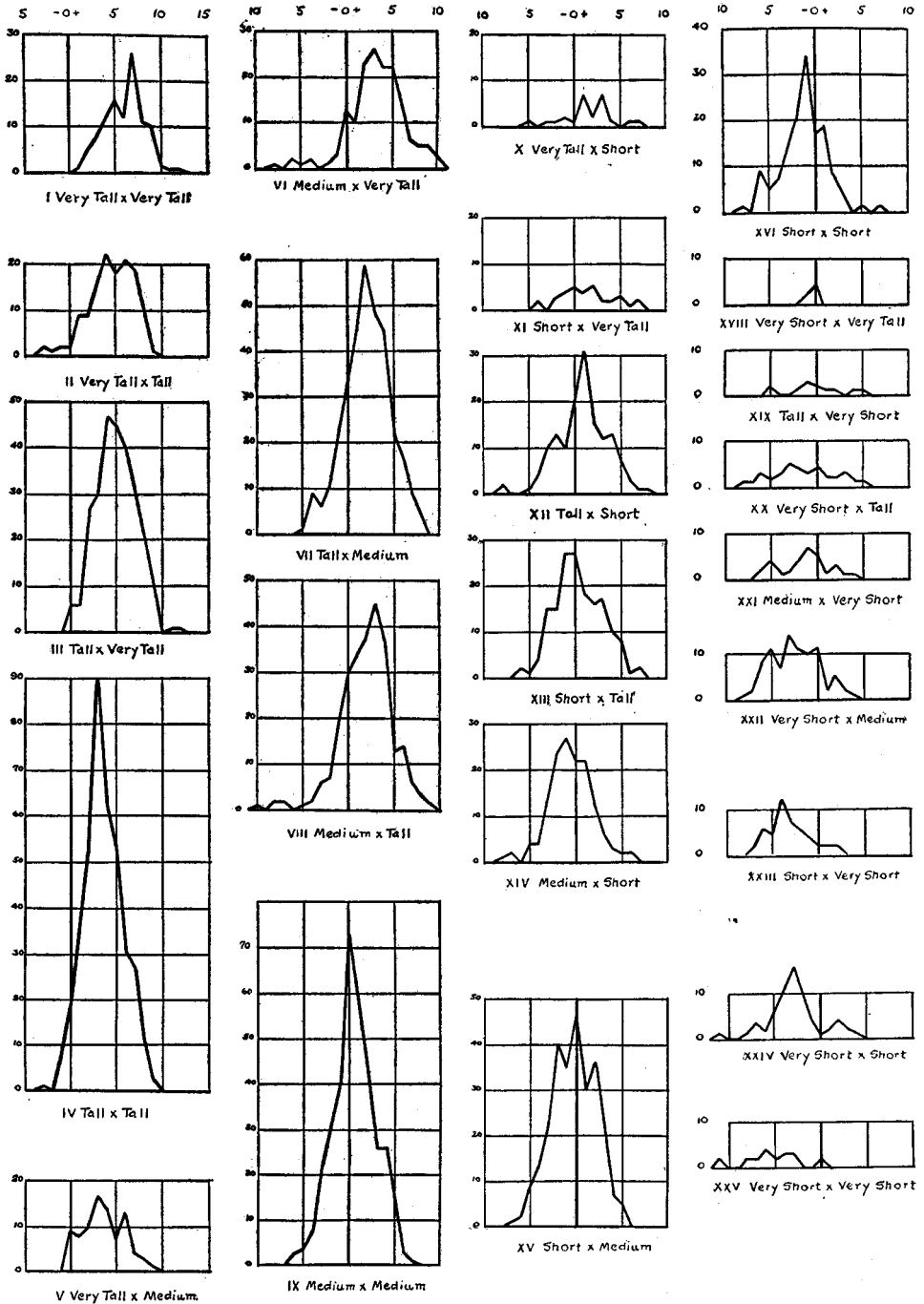
FIGURE 2.—Twenty-four polygons of frequency of the various deviations from the mean stature (for their sex) shown by the progeny of the indicated matings. Abscissae in inches.

have to complete our families by statements of relatives as to their recollection of the stature of the "grandparents."

2. *Results*

Let us now examine the few matings about which we have full data for 3 generations to learn if possible the nature of the general factors that make for stature. First I give all cases of matings of persons belonging respectively to tall and short strains. By "tall strain" I mean one in which the grandparents, parents and the sibs of the parents are all tall or at least above the average. By a "short strain" I mean one in which the grandparents, parents and sibs of the parents are all short or, at least, below the average. On account of small numbers I have added a few cases that merely closely approximate this ideal. The symbol +, without a figure, indicates "tall"; — indicates "short"; ±, medium; the number separated from the symbol by a comma gives the frequency.

a. Class I. Both parents tall of tall stock

Mating 1. Both parents are very tall and are at least of tall stock (table 6). This highly selected group of high parental statures (table 6) gives only tall offspring, the average of the children being about the same as the average of the parents. There is here no obvious regression, for the average deviation of the parents is +6 inches (or 5.8 inches) and that of the children is +6.8 inches. Surnames of these four families, so far as known, are: [HAYNES], PATTERSON, HOEING, (Kentucky), HELWIG. Two of these are German names and one is intermarried with a tall Kentucky family in part measured by myself. The other is without significance, as it is a name acquired by marriage. It seems clear that these four families, at least, —all that meet the conditions of "strain"—are without some at least of the shortening factors. All 23 children are at least tall and all but 5 are "very tall."

Mating 2. The fathers are very tall and of at least tall stock; the mothers are tall and of at least tall stock (table 7). The small group in table 7 is less highly selected than the last. It, too, gives almost exclusively at least tall children and shows no regression of deviation of children on parents. Thus the average deviation of the parents is +4.1 and of their children +5.2. The Davis family is from Kentucky and was, in part, measured by myself.

Mating 3. The fathers are "tall" and the mothers "very tall," and the stocks are at least tall (table 8). Table 8 is of special interest in comparison with table 6 for the question of sex-linked factors in statures. But, unfortunately, the numbers are not sufficient to decide the question

TABLE 6

Giving for each family the abmodality of stature (in inches) of father's parents, father, father's sibs, mother's parents, mother, mother's sibs, and the distribution of abmodalities in offspring.

Reference	FF	FM	F	F's sibs	MF	MM	M	M's sibs	+ 11	10	9	8	7	6	5	4	3	2	1 +
													Offspring						
Hay—A	+	+6	+8	♂: +4, 1; +, 5 ♀: +7, 1	+4	+3	+5	♂: +, 2; ±, 3	1	2						1			
Pat—B	+4	+5	+6	♂: +6, 2; +2, 3 ♀: +5, 2	+2	+5	+5	♂: +6, 1; +4, 1; ♀: +2, 1; 0, 1; +9, 1; +5, 1;			5	1		1			1		
Hoeing	+1	+4	+5	♂: +8, 1; +3, 1 ♀: +9, 1	x	+13	+7	♂: +3, 1					3	1	1				
Hel—A	+3	+8	+5	♂: +5, 1; +3, 1 ♀: +9, 1; +8, 1	+2	+3	+7	♀: +6, 1						1	2	2	1	1	2
Total									1	2	5	1	3	3	3	3	2	1	2

on these data alone. The children have a higher average + deviation when the mothers are very tall than when the fathers are very tall. The average deviations of sons and daughters is as 4.5 : 5.7 in the former and as 3.9 : 4.3 in the latter sort of mating. So that the deviation of

TABLE 7

Giving abmodalities of tall parental stocks and distribution of abmodalities in offspring.

Reference	FF	FM	F	F's sibs	MF	MM	M	M's sibs	+8	7	6	5	4	3	2	+1
Ven—A	+	+	+6	♀ : ±, 1	+3	+	+4	♂ : +, 1 ♂♀ : +, 2; ±, 1		2						
Davis	+	+	+5	♂♀ : +4, 2 ♂ : —2, 1	+4	+5	+3	♂♀ : +, 1 ♂ : +, 1	1		1					
All—A	+4	+3	+5	♂♀ : —, 5 ♀ : —, 1	+4	+5	+2	♀ : +5, 1		1	1	1		1	1	1
Total									1	3	2	1	0	1	1	1

TABLE 8

Giving abmodalities of parental stocks in mating 3, and distribution of abmodalities in the offspring.

Reference	FF	FM	F	F's sibs	MF	MM	M	M's sibs	Offspring										Total
									+9	+8	7	6	5	4	3	2	+1	
Tow–B	+4	+7	+4	♂: +1, 1; ♀: +5, 1	+6	+7	+9	♂: +5, 1; +4, 1; ♀: +8, 3; +4, 1	1	1	1							
Cam–A	+2	+5	+4	♂: +1, 2; +8, 1; +6, 1;	+4	+4	+5	♂: +2, 1; +2, 1; ±0, 1; ♀: −5, 1; +4, 1;	1	1	1		1					
Hil–A	+8	+3	+4	♀: +2, 1; +6, 1	+2	+2	+5	+3, 1		1	3	2	3					
Low–A	+	+3	+4	♂: +, 5; ♀: +1, 4	+5	+2	+5	♂: +4, 1; +2, 2; ±0, 1; −2, 1										
Eld–I	+2	+3	+2		+2	+3	+6		1		2	2	1	1	1			
Wes–A	+4	+5	+4	♂: +, 3; ♀: +, 2	+2	+3	+5	♂: +, 1; ±, 1; ♀: ±, 1		1	1	1	1	1	1			
Kin–A	+2	+2	+2	♂: +3, 1; +2, 1; +1, 1; ♀: +3, 1; +2, 2	+8	+5	+5	♂: +2, 1; ♀: +4, 2	1	1				1				
Ben–A	+	+	+4		+	+	+5		1				1					
Fos–A	+	+	+2	♂: +, 1; ♀: +4, 1; ±0, 1; −1, 1; +5, 1	+11	+2	+5	♂: +4, 4; +, 1		1	1		3					
Bea–B	+4	+5	+4	♂: +4, 1; +7, 1; +6, 1;	+4	+5	+7	♂: +6, 1; +3, 1; ♀: +2, 1;	1		2		1		1		1	
Wil–2	+5	+3	+2	♀: +5, 1	+2	+5	+5	♀: +1, 1; +3, 1;				1		1	1	1		
Total									2	5	4	8	10	6	3	3	2	

the sons is slightly less than the daughters whether father or mother is the shorter.

Again, the average deviation of the offspring shows no regression on that of the parent; for the average deviation of the parents is 4.6 inches and that of the children is 5.4 inches. Here, again, the children of parents who both belong to tall stock are all at least tall.

TABLE 9

Giving abmodalities of parental stocks in mating 4, and distribution of abmodalities in the offspring.

Reference	FF	FM	F	F's sibs	MF	MM	M	M's sibs	+1	2	3	4	5	6	+7	Total
Mor—A	+4	+6	+4	♂: +6, 1; +4, 1; ♀: +2, 1	+4	+5	+4	♂: +4, 1; +2, 1 / ♀: +7, 2; +3, 1	1	1	1	1	1	2	1	
Lak—A	+2	+3	+3	♂: +7, 2; +6, 2	+2	+3	+4	♂: +7, 1; +6, 1 / ♀: +3, 2			3	1			1	
Ric—A	+4	+5	+4	♂: +2, 1; +1, 4; ♀: +3, 2; +2, 1	+4	+3	+3	♀: +4, 1; +3, 2; +2, 1; -1, 1; +4, 1						1		
Wen—3	+4	+2	+2	♂: +6, 1; +2, 1; ♀: +6, 1	+2	+3	+4	♂: +5, 1; +2, 1; +1, 1		1	1	1	1			
Cle—I	+3	+5	+2		+4	+7	+3	♂: +1, 1; +4, 1; +3, 2		1	2	4	2			
Get—A	+2	+3	+2	♂: +2, 5; +5, 1; +3, 1; ♀: +2, 2	+6	+4	+2	♂: +4, 1	4	4	2	2	2			
Wri—I	+5	+7	+3		+2	+3	+2		1	1					1	
								Total	3	7	7	8	6	3	3	

Mating 4. Both parents "tall" and of at least tall stocks (table 9). The matings of table 9, though less extremely selected than those of the others, yield only children above the average in stature and practically all tall or very tall. Again, there is no regression; for the average deviation of the parents is +3.0 and that of the offspring is +3.9 inches.

Considering generally the preceding four matings, we see that there

TABLE 10

Giving abmodalities of parental stocks in mating 1 (class II), and distribution of abmodalities in the offspring.

Reference	FF	FM	F	F's sibs	MF	MM	M	M's sibs	Offspring 4	5	6	7	8	Total
Dav	−	−	−8		−	+	−7	♂:+, ♀		2	2			
Lav	×	×	−9		×	×	−6		1				1	
Lom	×	×	−5		×	×	−7				1	2		
Rom	×	×	−5		×	×	−5		1	2	1	2	1	2
								Total	2	2	4	2	2	

is a diminution in the average stature of the children from 6.8 inches when both parents are over 4 inches tall to 3.9 inches when the parents are 2, 3, or 4 inches tall. Also that when parents are selected who belong to tall stocks (as determined by the stature of their close relatives) the children will not tend to be of more nearly medium stature than the parents but, rather, less mediocre. The inference that seems most immediately deducible from these facts is that there is a difference in the genes for stature carried by the "very tall" and by the "tall."

TABLE 11

Giving abnodalities of parental stocks in mating 2 (class II), and distribution of abnodalities in the offspring.

Reference	FF	FM	F	F's sibs	MF	MM	M	M's sibs	Offspring					
									2	3	4	5	6	7
Bol—A	—	—	—		—	—	—			2	2			
Pet—B	—	—	—2		—	—	—				1			1
Scu	—	—	—5		—	—	—		2					
Total									2	2	3	0	0	1

b. Class II. Both parents short of short stock

Mating 1. Both parents are "very short" and are of short stock (table 10). The data of table 10 are from measurements made by me or my assistant, Dr. ELIZABETH B. MUNCEY, upon certain families of Calabrians. Though the height of the grandparents is not known exactly in any case it is fair to assume that they were much below the average of Anglo-Saxons. The offspring have about the same range of stature as the parents. Their average deviation (—6 inches) is somewhat less than that of their parents (—6.5 inches).

Mating 2. One parent "very short," the other "short." All grandparents below medium. The reciprocals are combined into the one table (table 11). Though table 11 is small it is significant. It seems probable that here again there is a regression toward mediocrity on the part of the children.

Mating 3. Both parents "short" of short stock. This table is, unfortunately, a mere fragment.

Reference	FF	FM	F	F's sibs	MF	MM	M	M's sibs	Offspring 1	2	3
Sammelrath	—	—	—3		—	—	—2			1	

c. Class III. One parent of tall stock and the other of short stock

This mating is so important for the theory of inheritance of stature that I have made a special attempt to get examples of it but with slight success. In a few years, when the offspring of the matings of Italian men to Irish women in this country shall have grown up, this study can readily be made. I have only one family, that of LEO MUNAO born in Italy and his wife born in Ireland (of Scotch Irish parentage) and migrated to the United States when a baby, also one son not seen but was

FF	FM	F	F's sibs	MF	MM	M	M's sibs	Offspring 0	—1	—2
—1±	+?	—1.3	about ±0	+2?	+3	+5	+4, +1, —3?, +5, +5	1		1?

said by father to be 5 ft. 11 inches (in his shoes?) or +3 inches.

This case turns out not to be very useful; partly because the father's mother was said to be "taller than the father," which would make her 4 inches or more above the average (!) and partly because only one of

the grown children—a girl of 16 years, 160 cm (63 inches)—could be measured.

V. HYPOTHESIS

The tables of offspring of two short parents even of "short stock" show them all to be below average stature but, on the average, less extreme than the parents. This suggests the hypothesis that *"short" parents may, and frequently do, carry germ cells which lack the shortening factors, while in "tall" parents the gametes are more nearly homogeneous and all lack most of the shortening factors.*

VI. TEST OF THE HYPOTHESIS

On the hypothesis suggested above there is to be expected a difference in the degree of regression of the children of two tall and of two short parents. To see if there is such a difference we make use of our table 12, comprising all the distributions of children of the various matings. There are 3298 of these children as contrasted with the 928 of GALTON's table 11 in *"Natural Inheritance,"* p. 208. The column headed "Regression" is the significant one.

TABLE 12

Matings arranged in order of average departure of parents from medium stature; the average departure of the children of each mating; and the regression of children on parents. + *regression means filial regression toward mediocrity;* —, *filial regression from mediocrity.*

Matings	Average departure of parents from mediocrity	Average departure of children	Regression
Very tall × very tall	5.80	6.08	—0.28
Very tall × tall	4.45	4.74	—0.29
Medium × very tall	3.02	3.45	—0.43
Tall × tall	2.93	3.56	—0.63
Very tall × short	1.57	1.41	+0.16
Medium × tall	1.51	2.01	—0.50
Medium × medium	0.03	0.34	—0.31
Short × tall	0.03	0.59	—0.56
Medium × short	—1.45	—0.38	+1.07
Tall × very short	—1.53	—1.28	+0.25
Short × short	—2.75	—1.36	+1.39
Very short × medium	—3.37	—2.19	+1.18
Short × very short	—4.41	—3.01	+1.40
Very short × very short	—6.42	—5.33	+1.09

Table 12 shows clearly that regression of offspring toward mediocrity occurs, as GALTON found, when the parents are much below the average

$$\frac{vt}{x} \quad \frac{vt}{x} \quad \frac{t}{x} \quad \frac{t}{x} + \frac{m}{x} - \frac{m}{x} \quad \frac{s}{x} \quad \frac{s}{x} \quad \frac{vs}{x}$$
$$vt \quad t \quad t \quad m \quad m \quad s \quad s \quad vs \quad vs$$

Par. 5.8 4.4 2.9 1.5 .03 1.4 2.7 4.4 6.4
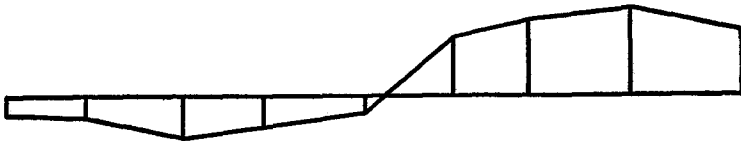
Regr. .28 .29 .63 .50 .31 1.07 1.3 1.4 1.09

− +

FIGURE 3.—Curve of regression. The ordinates, measured from where the curve cuts the base, give the average parental deviation from mediocrity of each class (Par). The abcissae are proportional to the filial regression (Regr.); real regression is measured up from the base; absence of regression (i.e., *progression*) is measured down from the base line.

in stature. But when the parents are much above the average in stature there is no filial regression; the average of the children is even more extreme than that of the parents (fig. 3). If, now, one looks at GALTON's table, one finds there, too, that regression is most marked in the offspring of short parents; there is little evidence of it in the off-spring of the very tallest parents.*

What is the meaning of this difference in regression of the offspring of tall and of short parents? GALTON explained regression as due to "inheritance from the whole population" and not parents merely. To-day we think of regression as due to the presence of recessive genes;

*GALTON's table II gives the following results:

Height of mid-parent in inches	Median value of children's stature	Regression in inches	Height of mid-parent in inches	Median value of children's stature	Regression in inches
Over 72.5	Circa 72.9**	none	68.5	68.2	0.3
72.5	72.2	0.3	67.5	67.6	0.1
71.5	69.9	1.6	66.5	67.2	0.7
70.5	69.5	1.0	65.5	66.7	1.2
69.5	68.9	0.6	64.5	65.8	1.3

**Only 4 entries from which to calculate the average.

genes, that is, which do not influence the phenotype. These recessive factors are commoner in short parents than in tall ones. We may infer that this is because the shorter parents have more dominant factors (and thus conceal more recessive allelomorphs) than taller parents. For taller parents, whose stature is determined largely by recessive factors, carry in their germ plasm less that is not expressed than do shorter parents. Hence resemblance to parents in stature is greater in the progeny of tall parents than in the progeny of short ones.

A second test of the hypothesis is found in the size of the index of variability (i. e., σ, the standard deviation).

TABLE 13

The standard deviations of the stature of offspring from the various matings arranged in order of size.

Mating	σ	$E\sigma$	Mating	σ	$E\sigma$
Tall × very short	3.22	± .22	Medium × short	2.41	± .06
Very tall × medium	2.80	± .09	Very short × very short	2.40	± .27
Very tall × short	2.74	± .17	Very tall × very tall	2.38	± .11
Tall × short	2.67	± .07	Short × short	2.33	± .09
Tall × medium	2.66	± .05	Medium × medium	2.25	± .06
Medium × very short	2.65	± .12	Very tall × tall	2.25	± .05
Short × very short	2.56	± .12	Tall × tall	2.11	± .05

Table 13 shows that the least variable offspring are those of two tall parents; also that matings of similars give rise to less variable progeny than matings of dissimilars. Thus tall × tall, medium × medium, short × short, very tall × very tall, very short × very short, are found in the lower half of the table and tall and very short, very tall and short, tall and short in the upper part of the table.

The meaning of this result is not perfectly clear, but it is about what would follow if parents of all classes are somewhat heterozygous, i. e., carry recessive factors. Then the recessive factors will be expressed phenotypically in a smaller proportion of the offspring when the parents are similar than when they are unlike; in the same way and for the same reason that among the offspring of 2 heterozygous brown-eyed parents only 25 percent have blue eyes, while from a simplex brown-eyed and a blue-eyed parent 50 percent of the progeny have blue eyes. In both cases the unlike matings give rise to the greater variability in the progeny. CASTLE and PHILLIPS (1914, p. 30), MULLER (1914, p. 574) and MacDOWELL (1916, p. 729) show that increased variability in F_1 is evidence of the presence of multiple factors.

From this table we see that the mating *medium* × *medium* gives rise

to a relatively slightly variable progeny. Now, since medium stature is often the product of *tall* × *short* it might be expected that the progeny of this mating would be especially variable. That such is not the case is probably due in part to the fact that most "medium" parents are not heterozygous for the extremes of stature. First, there exists, no doubt, a "medium" biotype which is more commonly represented in this country than any other; and, just because of its commonness, is less apt to be heterozygous than the short biotype. Extremes of tall and short offspring do, indeed, sometimes arise from two mediums but the pure mediums are so much more common than the hybrid mediums as to give the high concentration at the mode that is actually found.

Table 13 gives the standard deviation as a measure of absolute variability. But it is clear that, other things being equal, we should expect the individuals of a tall race to show more absolute variability in stature than those of a short race for the same reason that one expects a greater absolute variability in a series of measurements of a kilometer than of a dekameter. A fairer measure of variability would seem to be the coefficient of variability in which variability is expressed in units of the average height. The coefficients of variability are given in table 14, arranged according to size.

TABLE 14

Coefficients of variability of offspring of various classes of matings arranged in a decreasing series of size.

Mating	Coefficient of variability	Mating	Coefficient of variability
Tall × very short	.0483	Medium × tall	.0380
Very short × medium	.0402	Medium × short	.0357
Short × very short	.0394	Short × short	.0350
Very tall × short	.0394	Medium × medium	.0329
Medium × very tall	.0392	Very tall × very tall	.0321
Short × tall	.0390	Very tall × tall	.0310
Very short × very short	.0384	Tall × tall	.0294

Table 14, more even than table 13, proves the relatively slight variability of the progeny of tall parents. In the upper part of this table short parents occur twice as often as tall while in the lower half of the table tall parents occur twice as often as short.

VII. SUMMARY AND CONCLUSIONS

Analysis of the data thus shows:

1. That similar matings yield in F_1 a less variable progeny than dis-

similar matings; and this is evidence that both tall and short parents carry a number of unlike factors for stature.

2. Among similar matings, the progeny of two short parents are more variable than the progeny of two tall parents; and this is evidence that short parents carry in the gametes a greater number of unlike factors for stature than do tall parents.

3. Regression of the filial stature toward mediocrity is absent when the parents are selected for great stature, but markedly present when the parents are short. This proves that the gametes of tall parents are less varied (more extreme) than those of short parents.

As we have seen, low variability of progeny indicates that the genotypic factors of the parents are the recessive factors. The limiting case is that of parents of whom both show a monohybrid recessive trait; *all* of the children of such will be alike and show the recessive trait, while, on the other hand, if both parents show the dominant allelomorph and are heterozygous the children will vary greatly. It seems reasonable to conclude, therefore, that tall parents are such in consequence of the absence of certain dominant growth-repressing factors, rather than that short parents are such by an absence of positive, growth-promoting factors. One may conclude that shortness is due to certain positive factors that inhibit growth of the various parts.

C. Inheritance of the segments of stature

I. Statement of the problem

We have, hitherto, in this paper, considered stature as a whole. But, as we have seen, stature has been recognized since Galton's day as the resultant of numerous more or less independent variables. It is, in any case, a graduated character, is often cited as the most typical case of such, and is probably more often used than any other to illustrate variation in accordance with the binomial curve of frequency of variation.

During the last few years much attention has been paid to the inheritance of graduated or quantitative characters, in the studies of Nilsson-Ehle (1909, 1911), East (1910, 1916), Lang (1911, 1911 a), East and Hayes (1911), Emerson (1910, 1916), Belling (1912, 1915), Emerson and East (1913), Castle et al (1909), Goodspeed (1912, 1913, 1915), MacDowell (1914), Phillips (1912, 1914), Tammes (1911), Davenport (1911, 1913) and many others, and the theory that graduated characters result from multiple factors has become more and more firmly established.

1. *Correlation between segments of stature in the adult*

That human stature (or, indeed, the length of any animal) should prove to be a simple trait is hardly to be expected for the reasons already set forth. CASTLE (1914, pp. 51, 52) has, however, developed the idea that

". . . to a large extent the factors that determine size are *general* factors affecting all parts of the skeleton simultaneously. . . . Whatever special factors (if any) there are, which are concerned in limiting the size of particular bones, these can play only a subordinate part in determining size. The chief factors are plainly general factors and control the growth of the body as a whole."

The evidences upon which this conclusion is based are, for rabbits, correlations obtained between the length of various bones as follows:

Occipital to maxilla *and* zygoma posterior........	0.750
Occipital to maxilla *and* length of humerus.......	0.743
Occipital to maxilla *and* length of femur........	0.760
Occipital to maxilla *and* length of tibia..........	0.702
Length of zygoma posterior *and* humerus........	0.675
Length of zygoma posterior *and* femur length....	0.674
Length of zygoma posterior *and* tibia length......	0.658
Length of humerus *and* femur length............	0.857
Length of humerus *and* tibia length.............	0.791
Length of femur *and* tibia length...............	0.858

It will be noted that the high correlations are between head length, or head width (zygoma) on the one side and length of a leg bone on the other. Such pairs of dimensions do not enter into human stature. PEARSON and his co-workers calculated various correlations for man, some of which are very high; but these are mostly either between symmetrical organs, like right and left femur, or else between stature and one of its components, like femur length. Between stature and femur the correlation is 0.37; between clavicle and scapula, 0.12 to 0.16. On the other hand, PEARSON does find a high correlation between two independent elements of stature, viz., femur and tibia. This is given as 80 percent in the male and 89 percent in the female. But these determinations were made from a small amount of material (50 individuals of each sex) that was not at all homogeneous in age. I have had access to measurements of about 260 Harvard students taken by Dr. SARGENT and his assistants, made on men who were mostly 18 or 19 years of age. From these measurements the obviously undeveloped individuals

have been excluded. The correlation between "knee height" and "pubic arch" minus "knee height" is only 24 percent, with a probable error of 4 percent. That this correlation is so much less than PEARSON's (80 as contrasted with 24) is in part due to the fact that the knee height includes height of ankle, which is independently variable.

The correlation of all that stands above the "pubic arch" and all that stands below is also not high in the Harvard measurements, being only about 30 percent. That supra-pubic and sub-pubic portions of stature are to a certain extent dependent is obvious from the fact that "midgets" retain nearly the average proportion of parts. On the other hand, that they are to a certain extent independent is demonstrated in achondroplastic dwarfs in whom the trunk is of nearly normal size but the legs have failed to grow with the rest of the body (fig. 4). Marked differ-
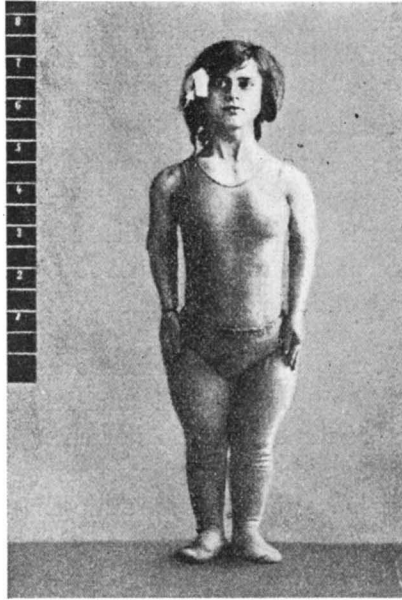

FIGURE 4.—"Cretinous" dwarf, representing the achondroplastic, short-legged type. From MARTIN 1914, p. 211.

ences in relative length of supra-pubic and sub-pubic portions of stature are seen in the anthropological "races." Thus the Australians and some negro groups have a relatively short trunk and long legs (fig. 5) while among Mongoloids, Eskimos, and some Amerindians the trunk is relatively long and the legs short (fig. 6).

The segments of the supra-pubic region—i. e., the supra-sternal and

sub-sternal—are independently variable. I find a correlation between them of only 9 percent, with a probable error of ±4[4]—a very small correlation.

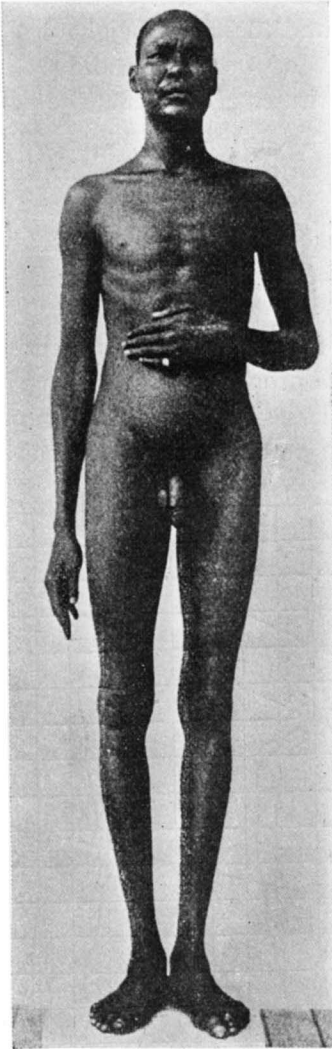The segments below the pubic arch, i. e., knee-to-pubic and knee-to-
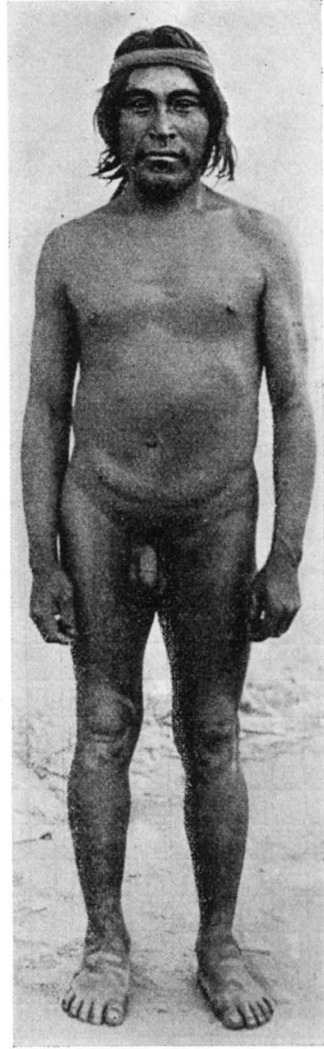

FIGURE 5   FIGURE 6

FIGURE 5.—Dinka negro. Photo. FRITSCH. From MARTIN 1914, p. 263.
FIGURE 6.—Chiriguan Indian. Photo. LEHMANN-NITSCHE. From MARTIN 1914, p. 263.

[4] All the correlations were calculated independently by three persons: J. A. HARRIS, MARY T. SCUDDER and C. B. DAVENPORT.

sole, have, as stated above, a correlation of 24 percent with a probable error of ±4. That the correlation of these two segments is not high we might expect, since certain persons have a relatively long thigh and others a relatively short thigh. The relatively long thigh is said to be the European type, here it constitutes about 50 percent of the whole leg length, while the fore leg is 41 percent and the ankle height 9 percent. A relatively short thigh is characteristic of the anthropoid apes. In the Chinese of Setschuan the thigh constitutes 48 percent; the fore leg 43 percent and the foot 9 percent of the leg (MARTIN 1914, pp. 314-15). In relation to total body length, the length of thigh varies in different races from 27 percent in Badeners to 23 percent in Japanese and Bugu of Africa. The lower leg varies from 24 percent among the Sikhs and certain African tribes (the Lobi, 25.7 percent) to 22 among the Badeners and Japanese.

Between standing and sitting height in the Harvard measurements there is a correlation of 0.64 ±.03. The proportion that sitting height is of stature varies in racial average. Thus sitting height is 53 percent of stature among Norwegians, 54 to 49 percent among various tribes
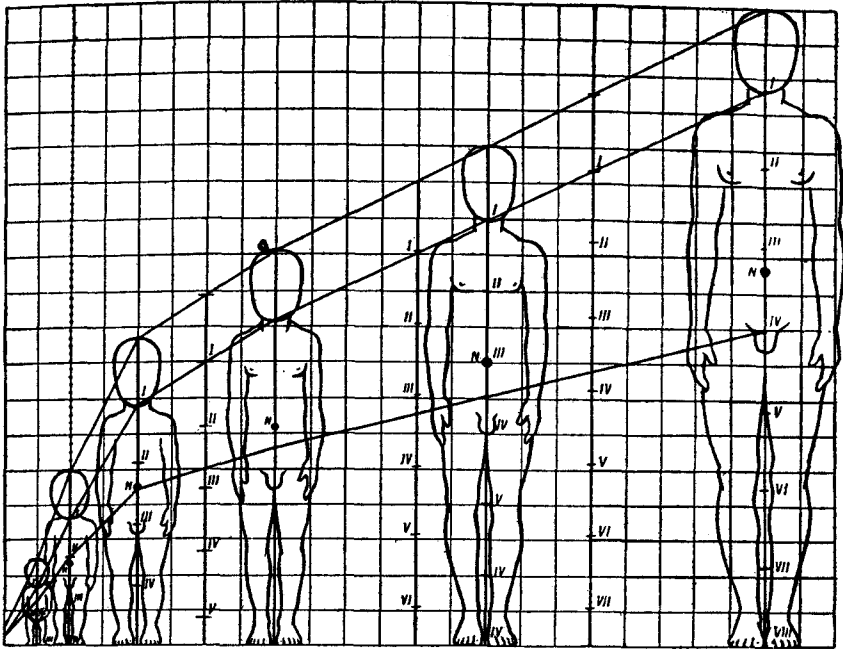

FIGURE 7.—Diagram showing absolute changes in total stature and length of segments of stature before birth, at birth (dotted line), at 2, 7, 12, and 20 years of age. Lines connect the vertices, chins, and middle points of stature of each figure. The principal vertical lines are spaced, using the head (vertex-chin) length as a unit. After STRATZ, from MARTIN 1914, 257.

of Africa and 46.5 among Australians. As HRDLICKA (1909) has shown, the proportional sitting height of adult races tends to decrease as the total stature of the race increases; this is well shown among the San Carlos Apaches (table 15, from MARTIN 1914, p. 260).

TABLE 15

Showing proportion of sitting height to total height in Apaches of both sexes and of various statures.

Total height in cm	Proportion of sitting height to stature ♂	♀	Total height in cm	Proportion of sitting height to stature ♂	♀
110 — 119.9	55.1	55.8	140 — 149.9	52.3	53.3
120 — 129.9	54.6	54.2	150 — 159.9	52.1	53.5
130 — 139.9	53.8	53.8	160 — 169.9	52.3	52.4

The conclusion that follows from a consideration of these data is that general factors control growth only to a degree that may be estimated as less than half. On the other hand, special factors are present that control, independently, the growth of the various elements that go to make up stature. And the graduated nature of the variations of stature must be largely due to the number of these independently varying units.

In view of the considerable independence in variability of the segments of stature, we are not surprised at our failure to find any simple "Mendelian" laws of inheritance of stature as a whole. Accordingly, it seemed desirable to study the inheritance of the different segments of stature.

2. *Developmental changes in relative length of segments of stature*

A casual comparison of an infant and a grown person suffices to show that the relative length of the segments of stature changes with age (figs. 7 and 8). Thus at birth, the length of head from vertex to chin is about 25 percent of the whole stature; in the adult it is about 12 percent. Similarly the length of leg is about 35 percent of stature in the infant and nearly 50 percent in the adult. The midpoint of stature is above the navel in the infant and below the "sacral arch" in the adult. Relatively, during development, head-and-neck changes least; the trunk next and the legs most of all.

In consequence of this change in proportions of the segments of stature—a change which does not cease altogether until after puberty—it is as impossible in family studies to make use of the proportions of undeveloped children as it is of their absolute dimensions.

II. MATERIAL AND METHODS

The difficulties in the way of getting precise data on the inheritance of the elements of stature are truly formidable. No collection of such data for *families* is, so far as I know, extant, and they can only be collected by specially trained persons. Also, there are obvious limitations to the detail of measurement that can be secured. To supply the deficiency in some degree the writer personally visited numerous families in the nearby village of Huntington, Long Island, and the city of Lexington, Kentucky, also among Italians in Brooklyn, New York, and secured their coöperation in his investigation. Dr. ELIZABETH B. MUNCEY, M.D., also assisted in measuring Italian families in Brooklyn and some families in Stamford, Conn., and Patchogue, Long Island. Except for a few measurements made by Miss MARY T. SCUDDER of Huntington and Miss VIRGINIA ANDERSON and Miss LUCILE CRUICK-SHANK of Lexington, all measurements were made by these two persons. The measurements were made by a "Seaver rod" manufactured by the NARRAGANSETT MACHINE COMPANY of Providence, R. I. Measurements were made mostly without shoes, but in a few cases the height of the heel was obtained separately and subtracted from the total stature.
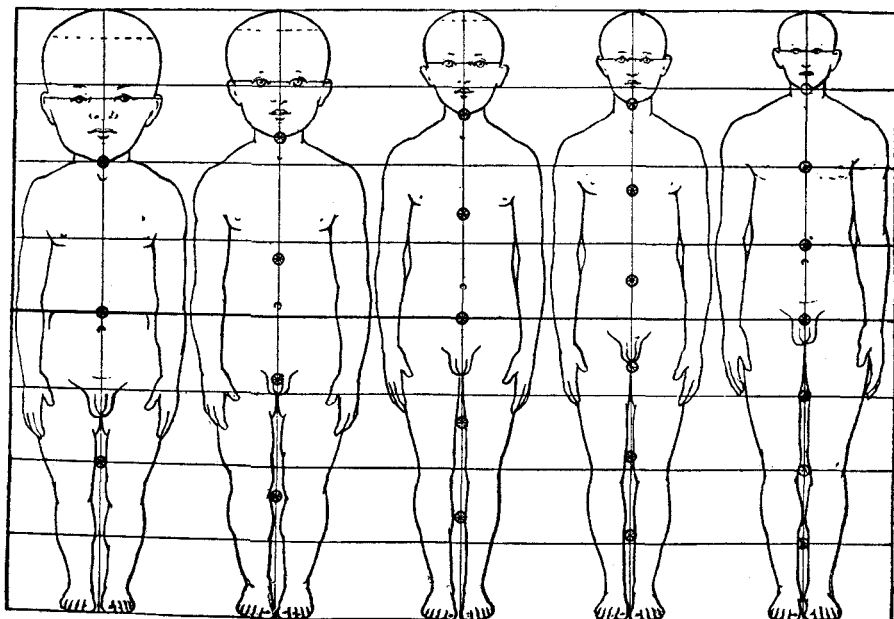
FIGURE 8.—Five outline human figures illustrating the changes in proportions of parts during development, total stature in all cases being taken at 100. The stages are selected such that the stature is respectively $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{7}$ and $\frac{1}{8}$ of face length. The proportional rise of the half-stature point from the navel to the pubis is shown by the heavy horizontal line. After STRATZ, from MARTIN 1914, p. 257.

The measurements were as follows:

1. Stature, either in stocking feet or with heel and sole subtracted;
2. Sitting height, from a flat chair seat to vertex;
3. Torso, from a flat chair seat to upper end of sternum (manubrium);
4. Height of fibula head (attachment of external lateral ligament) from floor.

From these measurements head and neck length is got by subtracting 3 from 2; and "femur" by the formula: (No. 1) — (No. 2) — (No. 4).

Since in this section we shall have often to deal with deviations from average or standard lengths of segments and with deviations from standard proportions it is desirable to give a table of such standards as have been adopted in this paper. This is done in table 16.

TABLE 16

Standard (average) length of the different segments of stature, in centimeters, and percentage that each is of the total stature.

| Name of measurement | Average length in centimeters | | Percentage of stature |
	♂	♀	♂ and ♀
Stature	173	160	100
Sitting height	91	85	53
Head and neck	32	29	18
Torso	59	56	35
"Femur"	37	34	21
"Fibula"	45	41	26

All data, with names and addresses, are permanently filed at the EUGENICS RECORD OFFICE.

III. MASS STUDIES ON VARIATION IN PROPORTIONS OF SEGMENTS OF STATURE

Human body stature has two clearly distinct portions—the trunk (including head and neck) and the legs. The proper dividing line between these two portions of stature is the upper edge of the symphysis pubis, because it lies at the same level with the head of the femur, i. e., passes through the center of the acetabulum. While it is quite practicable to determine the height of this line in gymnasia this is not practicable in homes with persons ordinarily dressed. The next best thing is to get *sitting height* which in a person of average stature is close to 10 cm greater than the vertex-symphysis dimension. Conversely the total stature minus sitting height is about 10 cm less than symphysis-sole height, or the total leg length.

The relative symphysis height and trunk + head length are given in table 17 (MARTIN 1914, p. 256) for various races. The figures for the two sexes (which are always closely similar) are here averaged.

TABLE 17

Racial differences in symphysis pubis height and trunk + head.

	Symphysis height	Trunk + head		Symphysis height	Trunk + head
Bushmen	53.0	47.0	Poles (also Belgians)	50.7	49.3
French	52.2	47.8	Whites of United States	50.3	49.7
Menangkabau-Malays	51.9	48.1	Kalmucks	50.1	49.9
Negroes of United States	51.8	48.2	Laplanders	50.0	50.0
M'Baka negroes	51.5	48.5	English	49.9	50.1
Kossacks	51.4	48.6	BaBinga	49.1	50.9
Tartars	50.7	49.3			

The ratio of sitting height to total stature (cural index) is naturally larger than that of trunk + head to stature. Some figures for different races, from MARTIN (1914, p. 260), are given in table 17 A.

TABLE 17 A

Giving for 4 races the ratio of sitting height to total stature.

	Sitting height		Sitting height
BaBinga negroes	53.6	English	52.4
Russian Jews	53.3	Belgian (also Norman-French)	52.3

In our families of English, Italian and German stock the range was from 50.6 to 57.5 percent and the mean about 53.0 for non-Italian and 53.5 for south Italian families.

The length of the trunk is measured by the distance between the symphysis pubis and the upper end of the episternum. This is a dimension that varies relatively as well as absolutely during development. Thus, from MARTIN (1914, p. 261, after SCHWERZ) we have for inhabitants of Schaffhausen the absolute and relative lengths of the trunk in the male sex shown in table 18.

TABLE 18

Trunk length and various ages.

Age-years	In centimeters absolute	Ratio trunk length / stature	Age-years	In centimeters absolute	Ratio trunk length / stature
6-7	33.8	29.6%	14-15	43.6	28.8
8-9	35.7	29.4	16-17	46.3	29.4
10-11	38.8	29.1	18-19	47.3	28.8
12-13	39.3	28.4	Over 20	49.5	29.3

Thus the trunk is relatively short at the age of 12 to 13 years. This

relative length of the trunk is different in different races. Again, following MARTIN (1914, p. 262) we have as in table 19:

TABLE 19

Ratio of trunk length to stature in various races.

Race	Percent	Race	Percent
Japanese of high rank	34.2	Mawambi—Pigmies of Africa	31.2
Australians	33.4	White Russian Jews	30.5
Chinese	33.1	Men of Baden	30.3
United States		French	29.4
(Amherst students)	31.8	Swiss	29.3

Figure 9 gives the relations between pubic height, trunk, and total stature in a number of young men (students at Harvard College) measured at the gymnasium under the direction of Dr. DUDLEY A. SARGENT. The measurements were made without clothes and are probably highly reliable. The range of pubic height is from 43.6 to 56.5
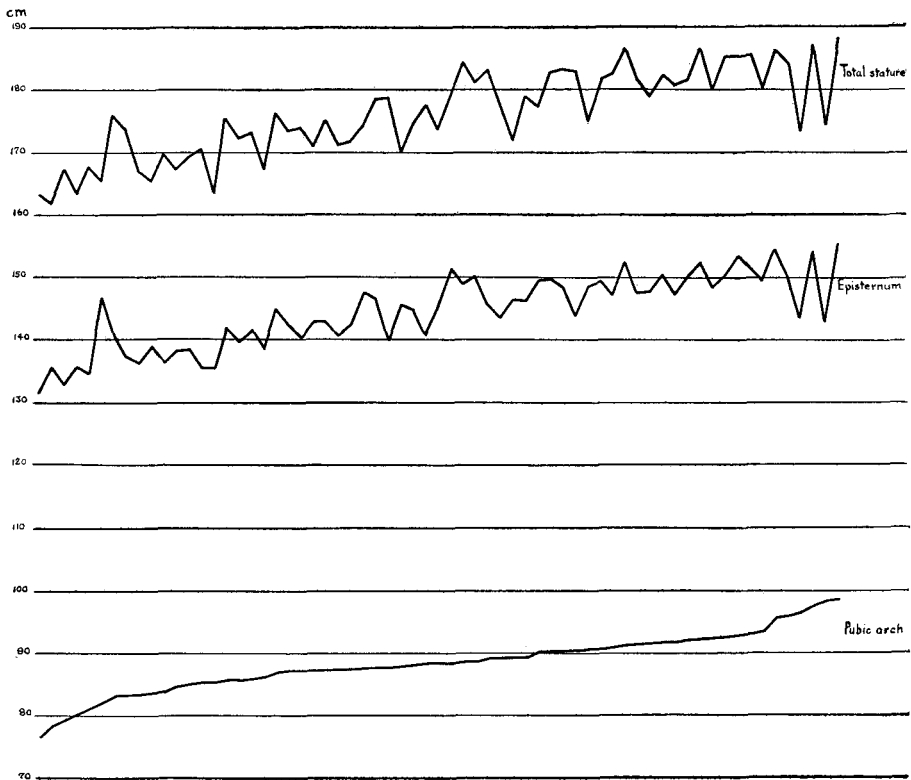

FIGURE 9.—"Ogive" curve of "pubic" heights of Harvard students with correlated height of "episternum" and total stature. The ordinates give lengths in centimeters.
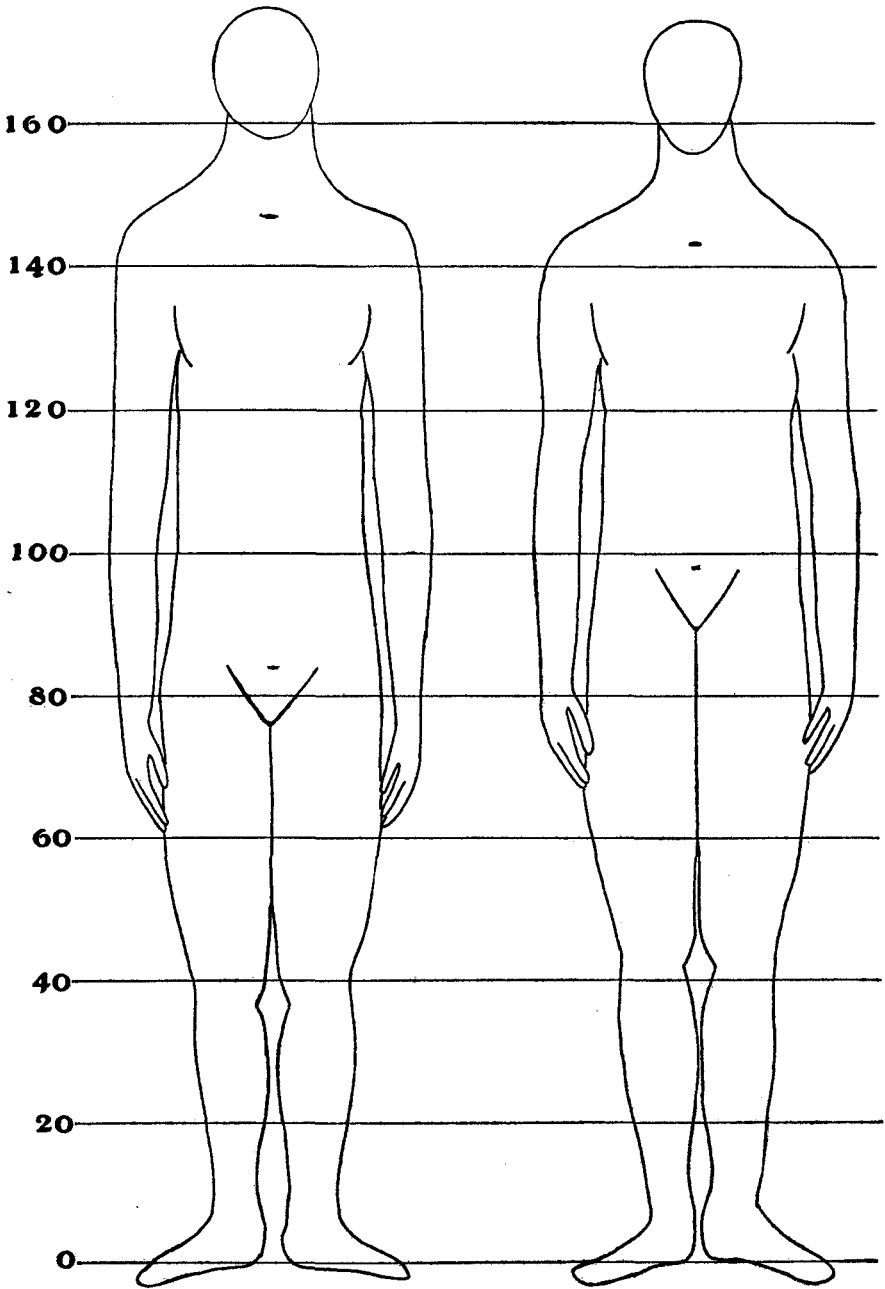
FIGURE 10.—Outlines of two males, aged about 20 years, each about 176 cm tall and selected for extreme unlikeness in torso length.

percent of the stature. The ratio of trunk length (i. e., symphysis pubis to episternum) to stature varies from 35 to 25.5 percent; the remainder of stature, the head and neck, is typically from 18.4 to 16.4 percent of the stature. Outlines of two of the individuals plotted in figure 9 who differ most widely in relation of torso length and height of pubic arch are given in figure 10.

IV. FAMILY STUDIES

The data for the studies in heredity of segments of stature were, as already stated, specially collected. They were originally all expressed in metric units and so this system is used in this section of the paper. As the segments selected were torso, fibula, head and neck, and "femur," our data will be discussed under these heads, except that "femur" being merely a residue, not an actual measurement and not agreeing with the length of the femur or thigh, this segment is not specially analyzed.

We shall first consider the family distribution of the absolute measures (or rather their deviation from mediocrity) of the 3 segments, and then the family distribution of the proportions that each bears to the whole stature.

1. *Inheritance of absolute length of stature segments in terms of deviation from the median*

a. Torso length

Discussion. Table 20 indicates that when *both* parents show long or short or medium torso, their children show the same, on the average. When one parent has long and the other short torso the children have (on the average) a torso that is shorter than the average torso of the whole population; a torso with average length of —1.78 cm from mediocrity. Again, long (or very long) $\times$ medium (thrown together) give children with torso a little (1.56 cm) above the average, but the mating short (or very short) $\times$ medium gives children that deviate strikingly from the mean in the direction of shortness. For, medium $\times$ very short gives a filial average of —3.18 cm and even medium $\times$ short a filial average of —1.56 cm. Short acts as though it is relatively stronger toward medium than is tall toward medium; a result that we should expect if "short" carried dominant factors.

As for the comparison of the filial standard deviation, this is complicated by the fact that (on account of small numbers) it has been necessary to make the parental range greater in some cases than in others.

TABLE 20

The distribution of frequencies of torso lengths in the children when the parents belong to the respective 8 stature groups represented. The filial measures are expressed in centimeters.

Deviation from mean of children, in cm	Eight groups of parental statures							
	1	2	3	4	5	6	7	8
	L × L VL × L L × VL VL × VL	VL × M L × M M × L M × L	VL × S L × S S × L S × VL	S × M M × S	S × S	VS × M M × VS	S × VS VS × S	M × M
+11								I
10				I				
9	I							
8	2	I						
7	I	I						
6	2	I						2
5	I	3	I	I				I
4	2	9		I	I			4
3	2	3		2	2		2	4
2	I	3	I	7	3			6
1	2	6	5	11	9	I	2	10
±0	I	6	2	18	7	I	3	7
—1	I	4	3	9	9	3	I	12
2		2	6	13	8		I	18
3		I	3	12	15		I	9
4		I	2	14	13	2		10
5		I	I	8	16	I·	5	5
6		I	I	5	6	I	3	5
7				I	9	2		2
8			I	I	3		I	
9			I					
10								2
n	16	43	27	104	101	11	19	98
Av. Dev.	+4.125	+1.558	—1.778	—1.558	—2.970	—3.182	—2.58	—1.286
σ	2.95	3.08	2.98	2.83	2.81	2.76	3.28	3.38

Thus, in the first column the parents are either very long or long (a group of wide range), but in column 5 both belong to the group of "short" (a group of slight range). Despite this, we can draw certain conclusions. Thus short × very short mating gives nearly the greatest variability of all and there are two offspring with a deviation of +3 cm and about 37 percent show a deviation of 0 or higher. On the other hand, the offspring of the long matings are practically all long (1 case of —1 cm) and only 13 percent have a deviation of 0 or under. The "short" group seems clearly to carry more recessive factors than the "long" group.

It is noteworthy that the progeny of two parents with medium torso should be clearly more variable than progeny of the mating very long

(or long) × short as 3.38 is to 2.98. This suggests that medium torso is not overwhelmingly commoner than long or short but that, on the contrary, the group of heterozygous mediums constitute an important fraction of the medium group; so that the progeny, through segregation of long and short components, are exceptionally variable.

b. Fibula length

Let us now consider the distribution of fibula length in the progeny of parents of selected fibula length (table 21).

TABLE 21

Distribution of fibula length in the progeny of parents of selected fibula length as indicated at head of each column.

Deviation from mean in cm— children	Ten groups of parental statures									
	1 L × L VL × L L × VL VL × VL	2 VL × M M × VL L × M M × L	3 VL × S S × VL L × S S × L	4 S × M M × S	5 M × VS VS × M	6 S × S	7 S × VS VS × S VS × VS	8 M × M	9 L × VS VS × L	10 VS × VL
+11	1									
10	1									
9		1								
8	2	1								
7	1									
6	2	3	1	1						
5	2	1						3		
4	8	8	2	1				2		
3	4	13	1	3	1	2		5		
2	3	18	7	10	2	2		9		1
1	2	16	8	10	1	2	1	10	2	
0		16	8	14		3		11	2	1
− 1		14	8	27	2	12	1	7	2	1
− 2		12	3	15	2	12	4	6		
− 3			1	6		9	5	5		
− 4		1	2	4	1	2	5	2		2
− 5				2		2	2	2		
− 6						1	2			
− 7						2	1			
− 8							3			
− 9										
−10										
−11							2			
n	26	104	41	93	9	49	26	62	6	5
Av. Dev.	+4.53	+1.16	+0.34	−0.56	−0.22	−1.82	−4.54	+0.23	0	−1.40
σ	2.58	2.29	2.03	1.95	2.20	2.14	2.97	2.39	0.82	2.33

Discussion. Table 21 shows that when both parents have long fibulas or both short fibulas or both medium fibulas they have progeny which, on the average, are like themselves respectively.

In this table the mating very long × very short gives chiefly short

progeny and long × long matings give no short; while short × short matings give about one-fifth of their progeny of mean or taller stature.

The greatest variability (2.97) is found in the offspring of short (or very short) × short. Long × long gives variable offspring but largely due to an extension in the positive end of the series. Short × medium gives in this case the lowest variability (1.95) but this cannot properly be compared with the very long (or long) × medium, with its greater parental range.

The variability of the progeny of the mating very long (or long) × short is in this case rather low (2.03) as compared with the variability of the progeny of two mediocre parents. This is as we found it in table 20.

c. Head and neck length

We have now to consider the distribution of length of head and neck in the progeny of parents of various classes of head and neck length.

Discussion. In table 22 we see that when both parents have a long suprasternal segment few or none of the progeny are medium or below

TABLE 22

Showing distribution of head and neck length in the progeny of parents of the nine classes of head and neck length, indicated in the tops of the columns.

Deviation from mean in cm—in children	Nine groups of parental statures								
	1 VL × L L × L L × VL VL × VL	2 VL × M M × VL L × M M × L	3 VL × S L × S S × VL S × L	4 S × M M × S	5 S × S	6 VS × M M × VS	7 S × VS VS × S	8 M × M	9 VS × L L × VS
+10		1							
8		2						1	
7								1	
6	1	3		1					
5	3	3	1	3	1			1	
4	2	13	2	2	1			5	
3		4	1	6	5	1		10	
2	2	16	4	16	2		1	11	1
1	1	14	3	23	9	2	4	17	1
± 0		16	1	17	6	2	3	21	
− 1	1	8	1	27	9	4	4	14	3
− 2		3		20	11	2	7	8	1
− 3		2	1	4	2	4	5	3	
− 4		1	1	2	3	1	1		
− 5		1		2	1	1	1		
− 6						1		1	
− 7				1					
− 8							1		
−10				1					
−15							1		
n	10	87	15	125	50	18	28	93	6
Av. Dev.	+3.30	+1.48	−1.27	− .10	− .34	−1.67	−2.41	+0.69	+0.33
σ	2.10	2.16	2.41	2.29	2.20	2.19	3.56	2.16	1.37

(1 in 10, or 10 percent), but when both parents have a short supra-sternal segment many of the children are medium or above (24 in 50, or 48 percent).

The most variable progeny are the offspring of short $\times$ very short parents; the least variable progeny are derived from very short $\times$ long matings. Next in size is from the very long (or long) $\times$ long matings ($\sigma = 2.10$); the medium $\times$ medium matings produce a slightly more variable progeny ($\sigma = 2.16$).

d. Summary

The examination of tables 20-22 shows conclusively first that the length of each segment of stature is more or less dependent on hereditary factors and that parents with short segments carry factors for long segment (or absence of shortness) more often than long segments carry factors for short segment. Thus in table 19 very long (or long) $\times$ long yields 12.5 percent of progeny 0 or shorter while very short (or short) $\times$ short yields 24.2 percent of progeny 0 or longer. In table 21 very long (or long) $\times$ long yields no progeny (in 26) who are 0 or shorter; but very short (or short) $\times$ short yields 10 in 75 (or 13.3 percent) who are 0 or taller. In table 22 very long (or long) $\times$ long yields 1 out of 10 (10 percent) 0 or shorter; while very short (or short) $\times$ short yields 41 percent 0 or longer. Thus in very short (or short) $\times$ short matings a full quarter of the progeny have the medium length of segment or longer. One cannot from these figures, however, reach any conclusion as to the number of factors involved.

The tables show also that, on the whole, the parental short lengths yield a more variable progeny than the parental great lengths; and that matings long $\times$ short have progeny with a relatively low variability. This result (which is not found in stature as a whole) is a familiar one in genetics and indicates that in the segments of stature we are approaching a condition of relatively few factors for the character.

2. Independence in inheritableness of segments of stature

a. Strains characterized by idiosyncrasies of particular segments

The observations recorded in the preceding section suggest that the lengths of the different segments of stature are inherited independently as is indicated particularly by the absence of a high correlation in their variability. If this is true we may expect to find strains characterized by idiosyncrasies of particular segments, and this proves, indeed, to be the case. Below, I give some examples from the families which are especially measured for this study.
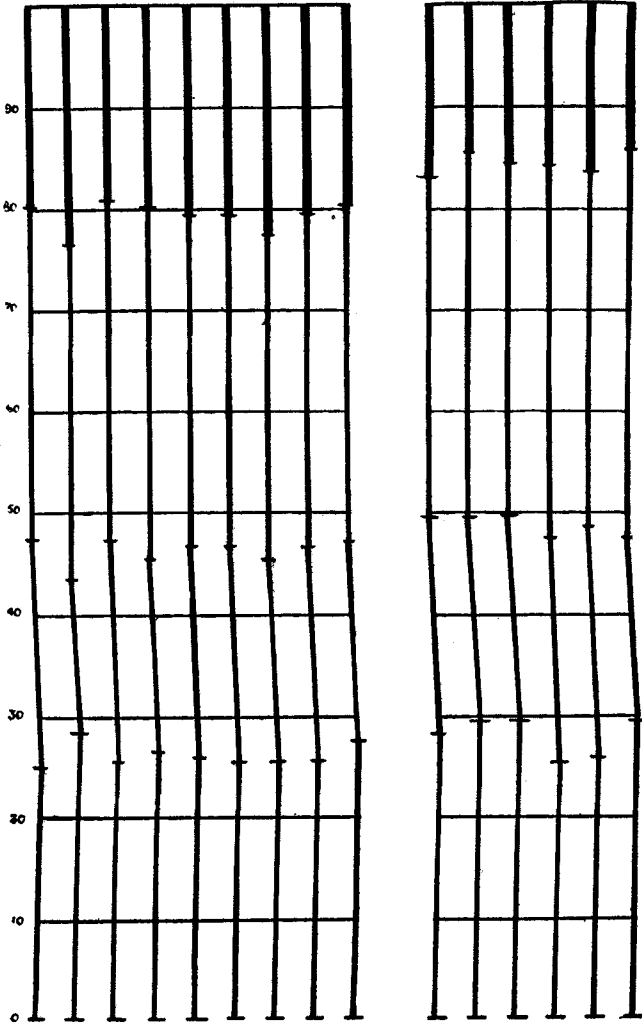
FIGURE 11   FIGURE 12

FIGURE 11.—Diagrams of proportions of segments of stature in a family character-
ized by long head and neck. The first diagram on the left is that of the father; the
second, that of the mother; the remainder, those of the progeny.

FIGURE 12.—Diagrams as in figure 11, except of a family characterized by short
head and neck.
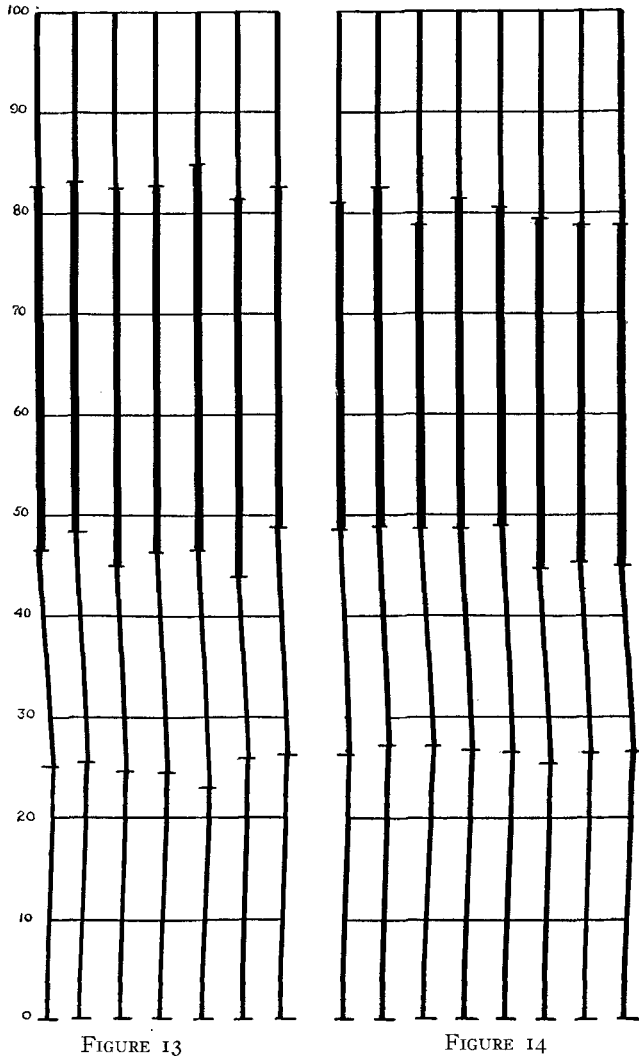
FIGURE 13   FIGURE 14

FIGURE 13.—Diagrams as in figure 11, of a family characterized by long torso.
FIGURE 14.—Diagrams as in figure 11, of a family characterized by short torso.
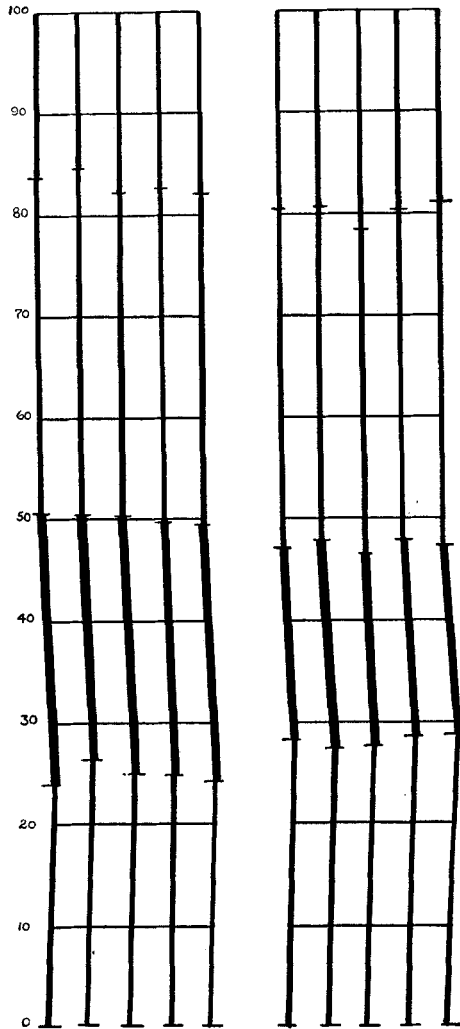
FIGURE 15   FIGURE 16

FIGURE 15.—Diagrams as in figure 11, of a family characterized by long thigh.
FIGURE 16.—Diagrams as in figure 11, of a family characterized by short thigh.

FIGURE 17   FIGURE 18

FIGURE 17.—Diagrams as in figure 11, of a family characterized by long fibula.
FIGURE 18.—Diagrams as in figure 11, of a family characterized by short fibula.

TABLE 23

Strains characterized by idiosyncracies of particular segments.

a. Long "neck + head" (fig. 11).

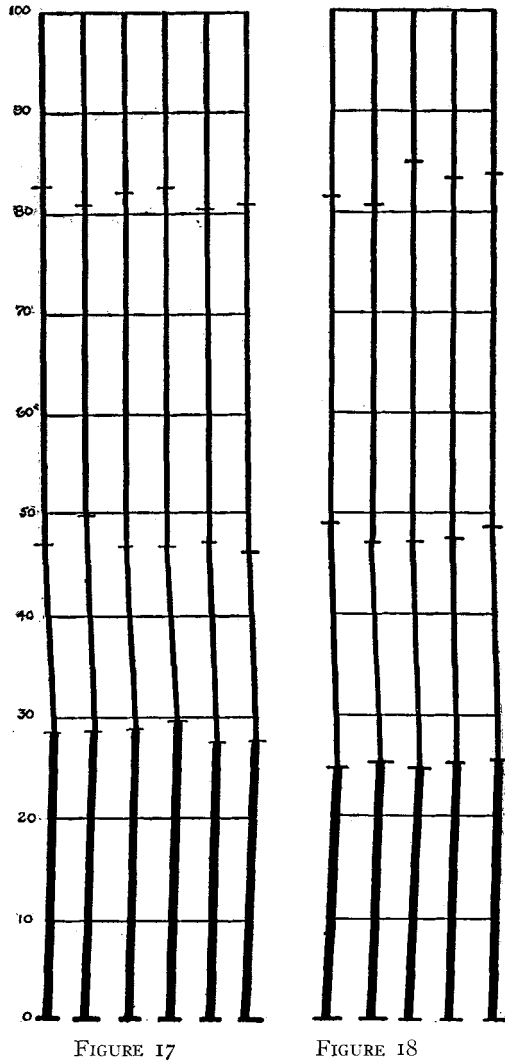|	
Cre., W.	F: 32.7 cm (+0.7) ; M: 30.5 cm (+1.5)
	dau. 1, 34.5 cm (+5.5) ; dau. 2, 32.8 cm (+3.8) ; dau. 3, 32.7 (+3.7)
Hog., E.	F: 34.5 cm (+2.5) ; M: 34.2 cm (+5.2)
	dau. 1, 34.6 cm (+5.6) ; dau. 2, 3.6 cm (+4.6) ; dau. 3, 30.2 cm (+1.2)
Rob.	F: 33 cm (+1.0) ; M: 33.2 cm (+4.2)
	son 1, 34 cm (+2.0) ; dau. 1, 29.4 cm (+0.4) ; son 2, 36 cm (+4.0)
Wal., M.	F: 33 cm (+1.0) ; M: 36.5 (+7.5)
	son 1, 35.5 cm (+3.5) ; son 2, 36.2 cm (+4.2) ; son 3, 39.3 cm (+7.3) ; son 4, 34.9 cm (+2.9) ; dau. 1, 31.0 cm (+2.0) ; dau. 2, 32.7 cm (+3.7) ; son 5, 30 cm (—2) [at 14 years].

b. Short "neck + head" (fig. 12).

Cal.	F: 29.6 cm (—2.4) ; M: 28 cm (—1.0)
	son 1, 25.2 cm (—6.8) ; dau. 2, 27.0 cm (—2.0)
Lav.	F: 26.0 cm (—6.0) ; M: 25.5 cm (—3.5)
	dau. 1, 26 cm (—3) ; son 1, 30 cm (—2.0)
Rou., A.	F: 31.1 cm (—0.9) ; M: 26.6 cm (—2.4)
	son 1, 30.7 cm (—1.3) ; son 2, 30.3 cm (—1.7) ; dau. 1, 26.8 cm (—2.2)

c. Long torso (fig. 13).

Gal., F.	F: 63 cm (+4) ; M: 57.5 cm (+1.5)
	dau. 1, 63 cm (+7) ; son 1, 65 cm (+6) ; son 2, 63.4 cm (+4.4) ; son 3, 66.5 cm (+7.5)
Hol., J.	F: 61.5 cm (+2.5) ; M: 57 cm (+1)
	son 1, 62 cm (+3) ; son 2, 63 cm (+4)

d. Short torso (fig. 14).

Bay., D.	F: 52 cm (—7) ; M: 53 cm (—3)
	dau. 1, 51 cm (—5) ; dau. 2.51 cm (—5) ; son 1, 57 cm (—2)
Bay., J.	F: 58.3 cm (—0.7) ; M: 51.7 cm (—4.3)
	dau. 1, 52.3 cm (—3.7) ; dau. 2, 53.5 cm (—2.5)
Cha., O.	F: 56.4 cm (—2.6) ; M: 53.4 cm (—2.6)
	dau. 1, 54.1 cm (—1.9) ; dau. 2, 49.7 cm (— 6.3) ; dau. 3, 49.9 cm (—6.1)
Con., J.	F: 55 cm (—4) ; M: 50.5 cm (—5.5)
	son 1, 52 cm (—7) ; son 2, 54.2 cm (—4.8) ; dau. 1, 52.7 cm (—3.3) ; son 3, 54.4 cm (—4.6) ; son 4, 55 cm (—4) ; dau. 2, 49 cm (—7)
Par. (Ital.)	F: 53.5 cm (—5.5) ; M: 49 cm (—7)
	son 1, 54.5 cm (—4.5) ; son 2, 52.0 cm (—7) ; son 3, 58 cm (—1) ; dau. 1, 52.5 cm (—3.5)

e. Long "femur" (fig. 15).

Bar., H.	F: 37.7 cm (+0.7) ; M: 36.2 cm (+2.2)
	dau. 1, 37.4 cm (+3.4) ; dau. 2, 35.2 cm (1.2)
Hur., R.	F: 38.5 cm (+1.5) ; M: 35 cm (+1)
	dau. 1, 35.7 cm (+1.7) ; son 1, 46 cm (+9)
Woo., W.	F: 44.4 cm (+7.4) ; M: 42.2 cm (+8.2)
	son 1, 46.4 cm (+9.4) ; son 2, 45.1 cm (+8.1) ; dau. 1, 43.1 cm (+9.1)

TABLE 23 (continued)

f. Short "femur" (fig. 16).

For., W.	F: 29.5 cm (—7.5) ; M: 31.5 cm (—2.5)
	dau. 1, 27.5 cm (—6.5) ; dau. 2, 25 cm (—9)
Gil., L.	F: 28 cm (—9) ; M: 32.8 cm (—1.2)
	dau. 1, 27.5 cm (—6.5) ; dau. 2, 33.3 cm (—0.7) ; dau. 3, 30.8 cm (—3.2) ;
	dau. 4, 31 cm (—3)
Rom. (Ital.)	F: 35.4 cm (—1.6) ; M: 28.5 cm (—5.5)
	son 1, 32.2 cm (—4.8) ; son 2, 29.3 cm (—7.7) ; son 3, 31 cm (—6) ; son 4,
	27.8 cm (—9.2 ; dau. 1, 33.7 cm (—0.3)
Sha., R.	F: 31.5 cm (—5.5) ; M: 31.5 cm (—2.5)
	son 1, 32.2 cm (—4.8) ; son 2, 31.5 cm (—5.5) ; son 3, 32.5 cm (—4.5)

g. Long "fibula" (fig. 17).

Gal., F.	F: 53 cm (+8) ; M: 47 cm (+6)
	son 1, 56 cm (+11) ; son 2, 49 cm (+4) ; dau. 1, 44 cm (+3) ; son 3,
	53 cm (+8)
Gav., L.	F: 50 cm (+5) ; M: 44 cm (+3)
	dau. 1, 43 cm (+2) ; dau. 2, 44 cm (+3) ; dau. 3, 42.5 cm (+1.5) ; dau. 4,
	44.5 cm (+3.5)
Scu., E.	F: 46 cm (+1) ; M: 41.5 cm (+0.5)
	son 1, 47 cm (+2) ; son 2, 46.5 cm (+1.5) ; son 3, 46.0 cm (+1.0) ; son 4,
	45.1 cm (+0.1)

h. Short "fibula" (fig. 18).

Bro., F.	F: 42 cm (—3) ; M: 40 cm (—1)
	son 1, 44 cm (—1) ; dau. 1, 41 cm (±0)
Hoy., B.	F: 43 cm (—2) ; M: 40.4 cm (—0.6)
	dau. 1, 40 cm (—1) ; son 1, 43.2 cm (—1.8)
Tro., A.	F: 40.6 cm (—4.4) ; M: 41 cm (±0)
(Ital.)	son 1, 43.7 cm (—1.3) ; dau. 1, 40.2 cm (—0.8)
Scu., T.	F: 44.8 cm (—0.2) ; M: 38.4 cm (—2.6)
	dau. 1, 39.9 cm (—1.1) ; dau. 2, 40.1 cm (—0.9) ; dau. 3, 37.5 cm (—3.5)

Table 23 indicates that there are families (potential biotypes) in our population characterized by idiosyncrasies in respect to length of each of the segments of stature that we have been considering. Were selections in marriage made with reference to length of torso or leg it is plain that biotypes having these idiosyncrasies might quickly become established.

b. Particulate inheritance of segments of stature

If the segments of stature are inherited independently of each other, then in a child the length of torso may depend upon hereditary elements derived from one side of the house and length of fibula upon elements derived from the other side of the house. Is this expectation realized?

Data for answering this question fully are not available and yet there are indicators that this is so. For example, in the family of M. Wal. (fig. 11) the head and neck measure is in the father 1 cm above medium and in the mother 7.5 above; in the second son it is +2.9 cm, resembling more that of the father. The femur of the father is ± 0; of the mother —10.5 cm, in the second son it is —5 cm, resembling thus the *mother* in being decidedly short although not so extremely short as in her case.

Again, in the Cros. family head and neck is —3.5 cm in the father; —0.5 cm in the mother and +2.0 in the third daughter who thus resembles more her mother. Femur is —3.5 in the father; +0.5 in the mother and —2.0 in the third daughter who thus resembles more her father in this respect.

Again, in the J. Con. family, the head and neck is ± 0 in the father; —2.5 cm in the mother and +4.3 in the eldest daughter who is in this respect more like the father. The fibula is —0.5 in the father; +0.5 in the mother, and +3.8 in the daughter who is more like her mother in this segment.

The foregoing are merely examples of which many more could be gathered from table 23. They support strongly the conclusion that the segments of stature are to a certain extent separately inheritable.

A consequence of the independent inheritableness of the segments of stature is that one child may inherit the longest segments from both parental germ-plasms and the other child of the same fraternity the shortest segments. The first may be taller than either parent and the other shorter. An example follows:

A. Gui. has a stature of +9; his wife of +15.8; their eldest daughter of +28.0. Each segment of stature of this daughter save one resembles in length the longer segments of the corresponding parental segments—in three segments the resemblance is to the mother, in one to the father. Again, in the Str. family, the father has a stature of —2.8 cm; the mother of —1.0 but the daughter of +5.7 cm. In head and neck measures the father is —1.5 cm; the mother +2.8, and the daughter +4.4, resembling more the mother. In torso the father is +0.5 cm; the mother —5.0; the daughter +0.2 resembling closely the father. In this case the tall daughter seems to get her tallness by a summation of tall factors for two segments from opposite sides of the house.

Such cases might be multiplied greatly. They lead to the conclusion

that one reason why children of two tall parents are sometimes (though rarely) shorter than the parents is because of the chance of union of the short factors for different segments from opposite sides of the house. In general, if *a b C d* be the factors carried by one parent, the capital letter representing a short segment, and *a B c d* be the factors carried by the other parent, then the progeny may be *a B C d* and thus have two shortening factors and be shorter than either parent.

3. *Inheritance of proportional lengths of stature segments*

Hitherto we have dealt with the absolute measures. In this section it is proposed to discuss the inheritance of *proportional* length; or the factors of stature contributed by the different segments when total stature is taken as 100.

a. Inheritance of proportional length of torso

First let us consider the case where both parents have relatively very long or long torsos.

TABLE 24

Mating: Long × long torso, and condition of torso in the progeny.

Family	Parents		Children			
	F	M	1	2	3	4
Gut.	+2.9	+3.1	+0.4	+2.5		
Gol.	+1.9	+2.5	+1.7	+0.5	+1.3	+0.1
Pia.	+1.0	+1.4	+1.3	+2.1	+0.3	
Big.	+2.1	+1.1	+2.0	—1.2		
Lav.	+1.4	+1.8	±0	—0.7		
Sha.	+5.2	+0.6	+3.6	—1.7		
Car.	+0.7	+2.4	+0.5	—1.9		
Wic.	+0.8	+0.8	—0.6			
Dav.	+0.6	+1.0	+1.3	—0.8	—0.9	+0.6

Table 24 shows that in the one mating where both parents have a very long torso the children (2) have likewise a torso above the average. When both parents have a torso which is 1 percent or more above the average there are about twice as many children with torso above the average length as below; and those above the average are far more extreme than those below the average. When merely one parent is "long" there is nearly an equal number of offspring above and below mediocrity.

Let us now compare the very short × very short matings. There are 4 of them.

TABLE 25

Mating: Very short × very short torso, and condition of torso in the progeny.

Family	Parents		Children		
	F	M	1	2	3
Pro.	—5.5	—2.6	—1.5		
Rob.	—3.7	—3.0	—3.0	+1.3	—2.3
Smi.	—3.5	—2.7	—2.9	—2.2	
Dar.	—2.7	—2.7	—3.6		

Of 7 children from the class of mating of table 25 all but 1 have relatively short to very short torso.

We may now consider other matings into which "short" (or very short) enters with or without "long" torso.

While the number of individuals considered in table 26 is too small to make it worth while to calculate the elements of the distribution in

TABLE 26

Distribution of torso length in offspring of various matings as indicated at top of column.

Percentage filial deviation from normal	Column number and mating				
	1 S　VS ×　× VS　S	2 S × S	3 VL　S ×　× S　VL	4 L　VS ×　× VS　L	5 L　S ×　× S　L
+3.0 to +2.6					1
+2.5 to +2.1		1			
+2.0 to +1.6	2	2			3
+1.5 to +1.1		1	1	1	1
+1.0 to +0.6	3	2	1	1	1
+0.5 to +0.1		7		3	5
±0.0 to —0.4	2	9			10
—0.5 to —0.9	4	8	4	4	8
—1.0 to —1.4	3	14		4	13
—1.5 to —1.9	6	11	1	4	7
—2.0 to —2.4	5	22	2	3	4
—2.5 to —2.9	2	5		3	1
—3.0 to —3.4	2	9		2	1
—3.5 to —3.9		4	1	2	2
—4.0 to —4.4	1	3			
—4.5 to —4.9		1			
—5.0 to —5.4					
—5.5 to —5.9	1				

each column, it is obvious by inspection that: (a) The offspring of short × very short have the greatest variability and extend their range in the direction of shortness more than any other mating. The progeny of short × short show a greater tendency to concentrate—a smaller variability. Long × short has a mode not far from o but clearly nega-

TABLE 27

Distribution of proportional torso length in offspring of matings in which one parent has a medium torso.

Percentage filial deviation from normal	Column number and mating				
	1 M × M	2 M × S S × M	3 M × VS VS × M	4 M × L L × M	5 VL × M M × VL
+5.0 to +4.6		1			
+4.5 to +4.1					
+4.0 to +3.6					
+3.5 to +3.1				2	
+3.0 to +2.6				1	
+2.5 to +2.1		1			1
+2.0 to +1.6		1		2	1
+1.5 to +1.1		1		5	1
+1.0 to +0.6		7		3	1
+0.5 to +0.1	2	5	7	1	1
±0.0 to —0.4	2	13	3	3	1
—0.5 to —0.9	2	12	1	3	
—1.0 to —1.4	3	10	4	7	2
—1.5 to —1.9	2	14	2	4	2
—2.0 to —2.4		6	2		1
—2.5 to —2.9		5	1	1	
—3.0 to —3.4	1	1		3	
—3.5 to —3.9		1			
—4.0 to —4.4			1		1
—4.5 to —4.9					
—5.0 to —5.4					
—5.5 to —5.9	1				

tive. In the short × very short mating (col. 1) two of the shortest individuals are from a single mating (Sch.: —4.0 × —0.6).

It will be noted that all matings between long and short (cols. 3, 4 and 5) yield many more short than long torso in the progeny in the proportion of 76 below to 18 above the average, or 4 : 1. This is, again, evidence of dominant factors in short torso.

Finally table 27 shows the distribution of progeny when one medium parent enters into the combination.

In table 27 the progeny of medium × short (or very short) mating averages relatively shorter than matings medium × long (or very long). It is remarkable, and probably due merely to insufficient numbers, that the progeny of two parents both with medium torso should have prevailingly relatively short torso. I cannot help entertaining a doubt as to the correctness of the two entries below —1.9 percent in the first column.

Summary. There is a clear evidence from table 26 of the dominance of one or more shortening factors in torso. Progeny of mating long (or very long) by short are in the proportion of 4 below mediocrity to 1 above. Short × short torso yields about 12 percent above mediocre torso. Medium × medium is very variable. The shortening factor in torso is, however, obviously not a single one.

b. Inheritance of proportional length of fibula

We will here consider first the distribution of progeny of similar matings (columns 1-5, table 28), then of matings between extremes (columns 6, 7) and finally of extremes with mediocrity (columns 8, 9).

First we note, in table 28, the reduction in the proportion of the fibula in the progeny *pari passu* with the reduction in the parental proportion. In the case of the long × long mating 23 percent of the progeny are at or below mediocrity. In the case of the short × short mating 45 percent of the progeny are above mediocrity. Here again the short condition clearly carries more allelomorphs than the long condition does. In the case of the medium × medium mating the average of the progeny lies close to mediocrity. The commonest condition is, indeed, close to the medium but there are more cases outside the range of "medium" than inside that range. Also the number of cases above the average is about the same as the number below. When short is mated to long (or very long) most of the progeny is below mediocrity (60 to 70 percent). The mating medium × short yields a great majority, about 75 percent, at or below the average; the mating medium × long yields about half above the average. There seems to be a slight evidence of a segregation into short and long again, as well as medium.

Some of the short × short matings yield a progeny of whom all have a relatively short fibula. Out of 8 matings that afford 2 or more children 3 yielded only offspring below average height and in two of these cases all offspring were "short" (i. e., —0.5 or shorter). There is a suggestion here that some of these parents were homozygous for short.

TABLE 28

Distribution of proportional "fibula" length in offspring of various matings.

Percentage filial deviation from normal	Column number and mating								
	1 VL × VL	2 VL × L	3 L × L	4 S × S	5 M × M	6 S × VL	7 S × L	8 M × S	9 M × L
+4.0 to +3.6	2						2		
+3.5 to +3.1			1						
+3.0 to +2.6		1	3						
+2.5 to +2.1		2	2	1	2		1		2
+2.0 to +1.6	1	3	10	1	2		1		2
+1.5 to +1.1	1	0	8	1	3		3	3	8
+1.0 to +0.6		6	9	4	13	1	6	7	8
+0.5 to +0.1		2	10	4	19	2	7	12	15
±0.0 to +0.4	2	1	5	3	12	5	3	27	21
−0.5 to −0.9		1	7	4	12	1	8	21	11
−1.0 to −1.4			1	2	5		18	21	6
−1.5 to −1.9				3	2	1	1	3	1
−2.0 to −2.4				1			1	2	
−2.5 to −2.9								0	
−3.0 to −3.4								1	

Of 20 long × long matings yielding 2 or more children 13 had no fibulas below the average proportions. In some families (Ford, 2; Conklin, 2; Shakeshaft, 3; Gerard, 4; Parisi, 4; Roselle, 3; Cozetti, 2) all offspring had "long" or "very long" fibulas. The Shakeshaft family is one of the most interesting in this regard. Father, +2.3 percent; mother, +1.0 percent; children: +1.8, +2.8, +3.0 respectively. The greater uniformity of the progeny of tall parents as compared with short indicates the factors that determine tallness are mainly recessive ones.

c. Inheritance of the proportional length of head and neck

This subject may be best introduced by a table giving the distribution of the progeny in all matings (table 29).

It is obvious that the length of head and neck is made up of many independently variable elements. The greatest variability arises from the combination of the germ-cells of two "short" parents and of two "long" ones, and least from two medium parents. Indeed, the offspring of two medium parents are closely massed around medium length, which indicates that "medium" is here not a typically heterozygous condition. Long × medium is heterozygous and has a rather high variability while short × medium, and long × short have a lower variability than either

TABLE 29

Distribution of deviations from average proportion of head and neck in the offspring of various matings.

Percentage filial deviation from normal		Column number and mating												
		1	2	3	4	5	6	7	8	9	10	11	12	13
		VL × VL	VL × L	VL × M	VL × S	L × L	L × M	L × S	L × VS	M × M	M × S	M × VS	S × S	S × VS
+5.8	11						1							
5.3	10					1								
4.8	9													
4.3	8		2											
3.8	7		1			1		1			1		2	
3.3	6	1	1	1		4	4				2		1	
2.8	5		2	1	1	3	6			2	1			
2.3	4	1	5	2	1	9	8	3		2	1		2	
1.8	3		2		2	10	14	5	1	3	8			1
1.3	2		1			8	14	2		3	2	1	2	
0.8	1		2		2	7	24	9		9	7	2		
0.3	0		5	1	1	13	16	2	1	10	15	1	6	1
—0.2	1		3	2	3	7	14	5	1	8	8	2	10	1
—0.7	2				1	1	8	5		3	10		4	1
—1.2	3					2	1	4		1	3		2	
—1.7	4						2	1	1	1	1			1
—2.2	5					2	1	1	2				1	2
—2.7	6			1			1				1			
—3.2	7									1	1			
—3.8	8								*					1†
σ						1.422	1.367	1.302		1.129	1.318		1.422	

*One case at —6.2 is omitted. †One case at —7.9 (probably erroneous or pathological).

short × short, or long × long. The results indicate that head and neck length depends upon a complex of factors which require further analysis.

V. SUMMARY

It appears that the inheritance of proportional length of the segments of stature is as evident as the inheritance of absolute differences. Here, too, it is obvious that the proportional shortness of any segment depends on more than one shortening factor—just how many cannot be said. Short × short gives practically always a more variable progeny than long × long, indicating that there are fewer factors in the germ-plasm of tall than of short parents. Medium stature is often found in the progeny of tall × short; but there is a very numerous medium biotype which tends to breed true; so that the medium × medium mating is not always characterized by excessive variability.

D. STATURE IN SPECIAL CLASSES

I. INFANTS

Infantile measures are difficult to obtain with accuracy because of the constant activity of the infant. Through the kind coöperation of Dr. FISHBERG I was permitted to measure 12 infants 1 to 9 days after birth at the JEWISH MATERNITY HOSPITAL, New York City. The total length (vertex to sole) varied from 47 to 52 cm.

The proportions found are given in table 30.

TABLE 30

Proportional length of the four segments of stature in 12 Jewish infants, 1—9 days old.

	1	2	3	4	5	6	7	8	9	10	11	12	Average
Vertex to sternum	22	21	24	21	20	25	24	22	23	19	22	20	21.9
Torso	46	44	46	46	48	44	48	50	46	50	49	47	47.0
Femur	12	14	10	12	10	13	11	9	11	14	10	11	11.4
Fibula	20	21	20	21	22	18	17	19	20	17	19	22	19.7

Comparing with our standard adult proportions (respectively, 18, 35, 21, 26) we see that the length of head and neck of infants is relatively great, that of torso is great, that of femur is only about relatively half of the adult and that of the fibula is short.

II. NEGROES

If the different anthropological "races" show a difference in proportions of the partial stature, that is evidence of the inheritance of the difference. On the occasion of a visit to Lexington, Kentucky, I was permitted to measure, through the courtesy of the superintendent of the STATE HOSPITAL and the coöperation of his wards, 12 "negro" men and 7 "negro" women. The average stature of the 12 negroes, eight of whom were probably of full blood and the others ¼ white, was 166.75 cm; but this included one dwarfish man of a stature of 150 cm. Omitting him the average stature of the male group is 168.3 cm which is about 5 cm smaller than the number used in this paper as the average stature of a white population. The stature found for conscript negroes and mulattoes by BAXTER (1875) in the U. S. was 169.3 cm. The average of the women measured by me was 157.8 cm which was about 2 cm shorter than our standard (160 cm).

The fibula in every case exceeded our standard of 26 percent of the entire stature and varied from 26.8 to 28.7 percent. The femur was slightly longer than the average. The torso was almost invariably shorter and sometimes very much shorter than our standard of 35 per-

cent. Thus it ranged from 29.2 to 33.1 and in one case to 35.5 percent. The relatively longer fibula and short torso are anthropoid characters. The head and neck of the negroes is generally in excess of the standard,

TABLE 31

Giving for each of 19 negroes, sex, age, total stature and, for each of the segments of stature, absolute length (in centimeters), percentage of stature, also deviation from absolute average length and deviation from average percentage of stature.

Sex	Stature	Head and neck	%	Torso	%	Femur	%	Fibula	%
♂	166.4	32.8	*19.7*	50.6	*30.4*	38.6	*23.2*	44.4	*26.7*
	—6.6	+0.8	(+*1.7*)	—8.4	(—*4.6*)	+1.6	(+*2.2*)	—0.6	(+*0.7*)
♂	171.7	32.8	*19.0*	54.2	*31.5*	38.5	*22.6*	46.2	*26.9*
	—1.3	+0.8	(+*1.0*)	—4.8	(—*3.5*)	+1.5	(+*1.6*)	+1.2	(+*0.9*)
♂	170.3	35.3	*20.7*	49.6	*29.2*	37.9	*22.2*	47.5	*27.9*
	—2.7	+3.3	(+*2.7*)	—9.4	(—*5.8*)	+0.9	(+*1.2*)	+2.5	(+*1.9*)
♂	168	30.7	*18.3*	52.1	*31.0*	38.0	*22.6*	47.2	*28.1*
	—5	—1.3	(+*0.3*)	—6.9	(—*4.0*)	+1	(+*1.6*)	+2.2	(+*2.1*)
♂	150.1	27.4	*18.3*	53.3	*35.5*	29.2	*19.4*	40.2	*26.8*
	—22.9	—4.6	(+*0.3*)	—5.7	(+*0.5*)	—7.8	(—*1.6*)	—4.8	(+*0.8*)
♂	172.7	32.1	*18.5*	54.3	*31.5*	37.6	*21.7*	48.7	*28.3*
	—0.3	+0.1	(+*0.5*)	—4.7	(—*3.5*)	+0.6	(+*0.7*)	+3.7	(+*2.3*)
♂	168.9	32.2	*19.1*	54.8	*32.5*	34.9	*20.6*	47.0	*27.8*
	—4.1	+0.2	(+*1.1*)	—4.2	(—*2.5*)	—2.1	(—*0.4*)	+2.0	(+*1.8*)
♂	169.7	33.7	*19.8*	51.6	*30.5*	38.1	*22.4*	46.3	*27.3*
	—3.3	+1.7	(+*1.8*)	—7.4	(—*4.5*)	+1.1	(+*1.4*)	+1.3	(+*1.3*)
♂	165.5	32.9	*19.9*	50.8	*30.7*	36.0	*21.7*	45.8	*27.7*
	—7.5	+0.9	(+*1.9*)	—8.2	(—*4.3*)	—1.0	(+*0.7*)	+0.8	(+*1.7*)
♂	174.7	28.5	*16.3*	55.0	*31.5*	41.0	*23.5*	50.2	*28.7*
	+1.7	—3.5	(—*1.7*)	—4.0	(—*3.5*)	+4.0	(+*2.5*)	+5.2	(+*2.7*)
♂	161.8	28.1	*17.3*	53.7	*33.2*	35.0	*21.7*	45.0	*27.8*
	—11.2	—3.9	(—*0.7*)	—5.3	(—*1.8*)	—2.0	(+*0.7*)	±0	(+*1.8*)
♂	161.2	23.8	*14.7*	53.9	*33.5*	38.2	*23.7*	45.3	*28.1*
	—11.8	—8.2	(—*3.3*)	—5.1	(—*1.5*)	+1.2	(+*2.7*)	+0.3	(+*2.1*)
♀	163.7	31.2	*19.0*	52.8	*32.3*	34.5	*21.1*	45.2	*27.6*
	+3.7	+2.2	(+*1.0*)	—3.2	(—*2.7*)	+0.5	(+*0.1*)	+4.2	(+*1.6*)
♀	162.7	29.7	*18.2*	52.0	*32.0*	35.0	*21.5*	46.0	*28.3*
	+2.7	+0.7	(+*0.2*)	—4.0	(—*3.0*)	+1.0	(+*0.5*)	+5.0	(+*2.3*)
♀	157.8	30.2	*19.1*	52.8	*33.5*	30.8	*19.5*	44.0	*27.9*
	—2.2	+1.2	(+*1.1*)	—3.2	(—*1.5*)	—3.2	(—*1.5*)	+3.0	(+*1.9*)
♀	157.2	31.0	*19.7*	52.0	*33.1*	30.2	*19.2*	44.0	*28.0*
	—2.8	+2.0	(+*1.7*)	—4.0	(—*1.9*)	—3.8	(—*1.8*)	+3.0	(+*2.0*)
♀	156.3	27.8	*17.8*	51.7	*33.1*	33.1	*21.2*	43.7	*27.9*
	—3.7	—1.2	(—*0.2*)	—4.3	(—*1.9*)	—0.9	(+*0.2*)	+2.7	(+*1.9*)
♀	156.2	31.5	*20.1*	49.8	*31.9*	31.9	*20.5*	43.0	*27.5*
	—3.8	+2.5	(+*2.1*)	—6.2	(—*3.1*)	—2.1	(—*0.5*)	+2.0	(+*1.5*)
♀	151	30.2	*20.0*	48	*31.7*	30.3	*20.1*	42.5	*28.2*
	—9	+1.2	(+*2.0*)	—8.0	(—*3.3*)	—3.7	(—*0.9*)	+1.5	(+*2.2*)

except in the case of 2 men and 1 woman (who were probably not of full blood) and of an idiot with small cranium. This long head and neck is an infantile feature.

III. INDIANS

In September, 1916, I measured 11 "Indians" at the GOVERNMENTAL SCHOOL FOR INDIANS at Carlisle, Pennsylvania. Of these 9 were said to be full blood (table 32). All but two were under the average stature for males adopted in this paper. The head and neck was long, torso short and fibula slightly above the average, the "femur" being correspondingly short. In these respects the Indians measured, as compared with our standard, show a deviation toward the infantile type—a result quite unanticipated by me.

IV. CRETINS

For comparison I introduce (table 33) measurements taken on some cretins (5 females and 2 males) at Randall's Island—these all untreated with thyro-iodine. Their deficiency in stature varied from 64 to 25 cm. In all cases the head and neck were above the average (from 2 to 6 percent). In only one case is the proportional length of torso shorter than the average. In all the femur is abnormally short (3.0 to 5.6 percent below the average). On the other hand the proportions of the fibula vary about the average. Long head and neck and short femur are the striking peculiarities; they are infantile conditions.

V. DWARFS AND HEREDITY OF DWARFISM

While short stature is a clear racial character, there are cases of extremely short stature which are clearly pathological or teratological. Of the so-called dwarf races, the Akka Negrilloes of Central Africa have a height of about 138 cm (male stature) and the Negritos of the Philippines of about 147 cm. But a number of adult dwarfs among the whites measuring under 100 cm in stature are known. Such dwarfs are of two principal types, achondroplastic and ateliotic—the former having short legs with long trunk, the latter normal proportions but small size (fig. 19). While achondroplasia is probably due to improper internal secretions, the cause of ateliosis is more uncertain. Heredity of these two types has been considered by RISCHBETH and BARRINGTON (1912) without reaching any conclusion other than that the abnormal heights tend to recur in families.

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TABLE 32

Giving for 11 Indians, at Carlisle Indian School, name, sex, age, stature and, for each of the segments of stature, absolute length (in centimeters), percentage of stature, also deviation from absolute average length and deviation from average percentage of stature.

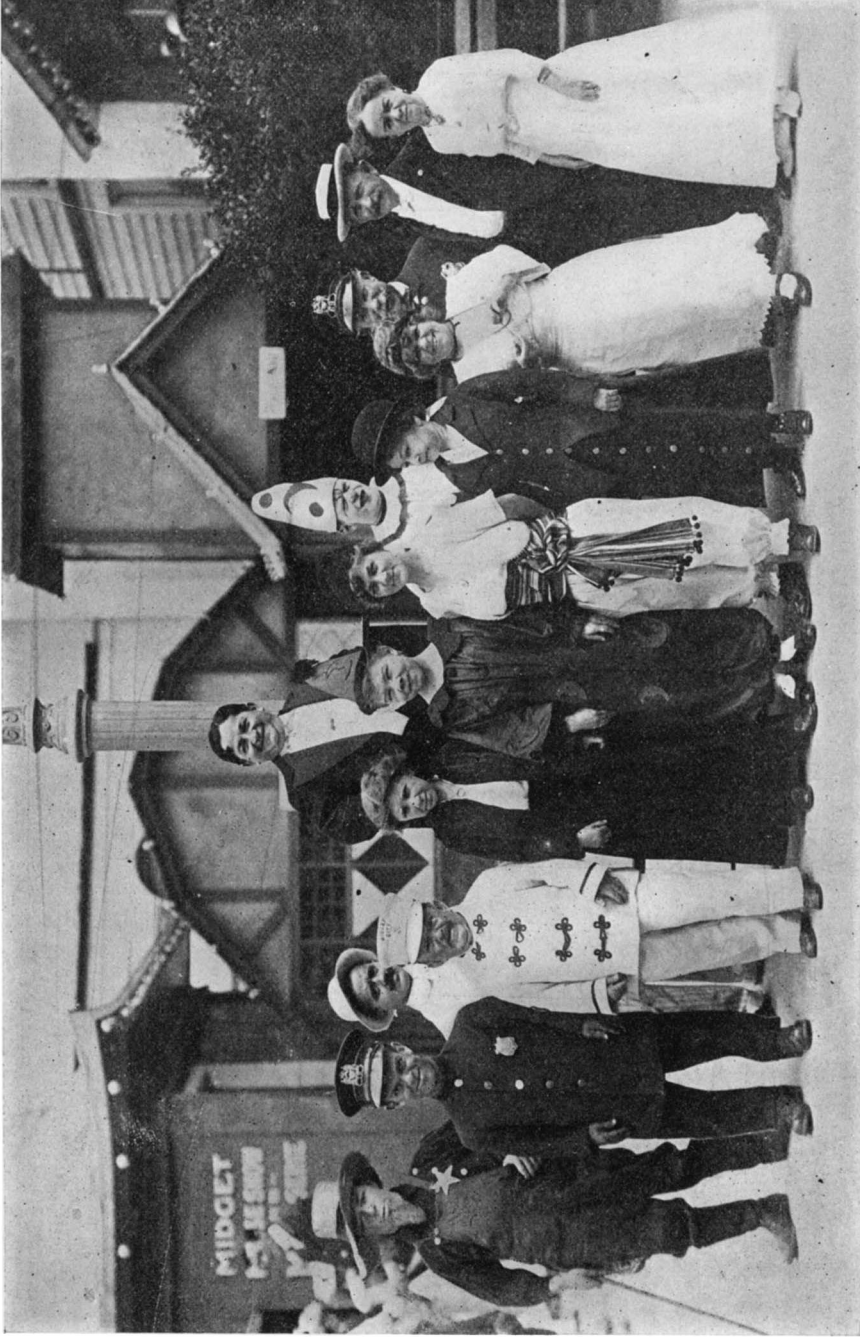| Reference	Sex	Age	Stature	Head and neck	%	Torso	%	Femur	%	Fibula	%	Tribe
Hampton Tho.	♂	24	166.6	35.0	*21.0*	54.0	*32.4*	35.5	*21.3*	42.1	*25.3*	Choctaw, Oklahoma
			−6.4	+3.0	*(+3.0)*	−5.0	*(−2.6)*	−1.5	*(+0.3)*	−2.9	*(−0.7)*	
Jno. Cha.	♂	23	165.5	32.4	*19.6*	55.0	*33.2*	34.4	*20.8*	43.7	*26.4*	Choctaw, New Mexico
			−7.5	+0.4	*(+1.6)*	−4.0	*(−1.8)*	−2.6	*(−0.2)*	−1.3	*(+0.4)*	
Joe Day	♂	21	166.6	32.4	*19.4*	58.4	*35.1*	32.8	*19.7*	43.0	*25.8*	Choctaw, New Mexico
			−6.4	+0.4	*(+1.4)*	−0.6	*(+0.1)*	−4.2	*(−1.3)*	−2.0	*(−0.2)*	
David Was.	♂	22	166.8	33.7	*20.2*	55.5	*33.3*	34.6	*20.7*	43.0	*25.8*	Creek, Oklahoma
			−6.2	+1.7	*(+2.2)*	−3.5	*(−1.7)*	−2.4	*(−0.3)*	−2.0	*(−0.2)*	
Alac Ene.	♂	18	174.0	31.9	*18.3*	57.2	*32.9*	38.7	*22.2*	46.2	*26.6*	Potowatan, Oklahoma
			+1.0	−0.1	*(+0.3)*	−1.8	*(−2.1)*	+1.7	*(+1.2)*	+1.2	*(+0.6)*	
Hobson Tup.	♂	18	179.5	34.2	*19.1*	57.5	*32.0*	40.3	*22.5*	47.5	*26.4*	Choctaw, Oklahoma
			+6.5	+2.2	*(+1.1)*	−1.5	*(−3.0)*	+3.3	*(+1.5)*	+2.5	*(+0.4)*	
Ellian Bru.	♂	17	162.6	32.7	*20.1*	53.3	*32.8*	35.6	*21.9*	41.0	*25.2*	Creek, Oklahoma
			−10.4	+0.7	*(+2.1)*	−5.7	*(−2.2)*	−1.4	*(−0.9)*	−4.0	*(−0.8)*	
Sampson Ben.	♂	21	171.2	33.3	*19.4*	58.7	*34.3*	34.2	*20.0*	45.0	*26.3*	Choctaw, Oklahoma
			−1.8	+1.3	*(+1.4)*	−0.3	*(−0.7)*	−2.8	*(−1.0)*	±0	*(+0.3)*	
Thomas Mon.	♂	20	160.0	32.1	*20.1*	54.0	*33.8*	31.9	*19.8*	42.0	*26.3*	Pueblo, New Mexico
			−13.0	+0.1	*(+2.1)*	−5.0	*(−1.2)*	−5.1	*(−1.2)*	−3.0	*(+0.3)*	
Frank Ant.	♂	17	168.0	32.2	*19.2*	60.0	*35.7*	34.7	*20.6*	41.1	*24.5*	Chippewa, ¾ blood, Wisconsin
			−5.0	+0.2	*(+1.2)*	+1.0	*(+0.7)*	−2.3	*(−0.4)*	−3.9	*(−1.5)*	
Joseph Pop.	♂	17	172.3	33.3	*19.3*	54.0	*31.4*	39.3	*22.8*	45.7	*26.5*	Chippewa, ½ blood, Minnesota
			−0.7	+1.3	*(+1.3)*	−5.0	*(−3.6)*	+2.3	*(+1.8)*	+0.7	*(+0.5)*	

FIGURE 19.—Photograph of a group of dwarfs and midgets exhibited at Luna Park, Coney Island, 1915. From left to right, Irwin Emmer, Samuel Goldstein, Louis Comadori, Baron Magri, Addie Frank, Joseph Zaino, Helen L. Haskell, Elsie King, Joe Short, Nona Appleby, Helen Linoner, Patrick McGoff, George Laible, Annie Nelson (Mrs. George Laible). Photograph by CHAS. NESENSOHN.

TABLE 33

Giving for each of 10 cretins, reference letters, sex, age, stature (absolute and by deviation from average) and, for each of the segments of stature, absolute length (in centimeters), percentage of stature, also deviation from absolute average length and deviation from average percentage of stature.

Reference	Sex	Age	Stature	Head and neck	%	Torso	%	Femur	%	Fibula	%
Rose Sor.	♀	14	118.4	24.7	20.8	42.2	35.7	21.9	18.5	29.6	25.0
			−41.6	−4.3	(+2.8)	−13.8	(+0.7)	−12.1	(−2.5)	−11.4	(−1.0)
Josephine Red.	♀	27	133.1	27.3	20.6	46.7	35.1	21.1	15.8	38.0	28.5
			−26.9	−1.7	(+2.6)	−9.3	(+0.1)	−12.9	(−5.2)	−3.0	(+2.5)
Sadie Gro.	♀	15	132.9	26.8	20.2	46.7	35.2	21.4	16.1	38.0	28.5
			−27.1	−2.2	(+2.2)	−9.3	(+0.2)	−12.6	(−4.9)	−3.0	(+2.5)
Hannah Sil.	♀	23	124.7	24.2	19.3	47.4	38.1	22.4	18.0	30.7	24.6
			−35.3	−4.8	(+1.3)	−8.6	(+3.1)	−11.6	(−3.0)	−10.3	(−1.4)
Mary Don.	♀	21	134.0	27.3	20.4	46.9	35.0	20.7	15.4	39.1	29.2
			−26.0	−1.7	(+2.4)	−9.1	(±0)	−13.3	(−5.6)	−1.9	(+3.2)
Katie Zae.	♀	33	103.6	22.5	21.7	39.0	37.7	18.5	17.8	23.6	22.8
			−56.4	−6.5	(+3.7)	−17.0	(+2.7)	−15.5	(−3.2)	−17.4	(−3.2)
Frances Pen.	♀	15	113.8	23.2	20.4	42.0	37.0	20.3	17.8	28.3	24.8
			−46.2	−5.8	(+2.4)	−14.0	(+2.0)	−13.7	(−3.2)	−12.7	(−1.2)
Becky Kle.	♀	14½	115.7	23.5	20.3	42.5	36.8	21.0	18.1	28.7	24.8
			−44.3	−5.5	(+2.3)	−13.5	(+1.8)	−13.0	(−2.9)	−12.3	(−1.2)
Bennie Lon.	♂	37	109.2	26.5	24.3	36.0	33.0	19.7	18.0	27.0	24.7
			−63.8	−5.5	(+6.3)	−23.0	(−2.0)	−17.3	(−3.0)	−18.0	(−1.3)
Jimmie Mur.	♂	19	128.7	24.7	19.2	49.0	38.1	21.3	16.5	33.7	26.2
			−44.3	−7.3	(+1.2)	−10.0	(+3.1)	−15.7	(−4.5)	−11.3	(+0.2)

1. *Achondroplasia*

An examination of the pedigrees of achondroplastic dwarfs in the *Treasury of Human Inheritance* shows a few families in which the abnormality passed through several generations without a break. Thus in No. 608 there are shown 5 generations of "little people" in direct line. In the first generations the progenitors are said to be small but not so small as the later descendants. In the third generation is an achondroplastic dwarf. He had, by a wife of normal size, 11 children of whom 4 died in infancy. Of the remaining 7, 5 are large and 2 are small. One of the large ones married a normal man and had 5 children of whom one was an achondroplastic dwarf and died at the age of 3 years. One of the small ones married an ateliotic dwarf and is said to have had an ateliotic son only about 60 cm tall. The other small one had, by a normal-sized man, a son and a daughter who died in infancy and also a daughter who is achondroplastic and about the height of her uals, all males, and about 132 cm tall.

The *Treasury* includes a number of cases of direct heredity through 3 generations. Some of these are briefly described here.

No. 613. A very small man, not over 150 cm tall and ateliotic, had several normal children and one daughter, achondroplastic and 115 cm tall. She had a daughter in turn and later a son, both achondroplastic like the mother. A third child was not achondroplastic.

No. 619. In three generations there are six achondroplastic individuals, all males, and about 132.0 cm tall.

No. 622. An achondroplastic man about 105 cm tall had two normal children, an achondroplastic daughter who died at 7½ years and an achondroplastic son 110 cm tall who in turn has 3 young children including one son who at 6 years shows the same anomalies as his father, height, 81.5 cm.

No. 623. A man and his son are both achondroplastic, about 135 cm tall. By a normal woman the latter has a son and two daughters. One of the latter is normal in stature (165 cm) but the other daughter, aged 27 years, is 118 cm tall with short legs; while the son, at 30 years, is 121 cm tall and short-legged.

No. 625. A dwarf had by a normal-sized woman "numerous" children. Two sons and a daughter are dwarfs. One of the sons is 160 cm tall with short appendages; he married a big woman who bore him 12 children besides having had 3 abortions. Four of the 12 are dead and 3 of the remaining 8 are achondroplastic like their father. They are

all girls and at 23, 21, and 19 years measure 95, 110, and 106 cm respectively. The father's brother, much smaller than the father, also had numerous children, mostly dwarfs.

No. 664. A "dwarf" had 8 children, of whom 6 were dwarfs, all, so far as known, achondroplastic. One such (123 cm tall) by a normal man had an achondroplastic daughter.

A number of other cases could be cited of achondroplastic dwarfism in parent and child.

On the other hand it is by no means true that one of the parents of an achondroplastic child is necessarily achondroplastic. Thus a girl at 26, 99 cm tall, and her brother, 25 years, 111 cm tall, had normal trunks but short legs. Both the father and the mother are normal and so are all other known close relatives, including 5 sibs.

Sometimes a generation is skipped. Thus in No. 620 a girl of ten is extremely achondroplastic, "suffering from typical rachitis." Her mother is normal and married to a big man. This mother's father was a dwarf with much curved short limbs.

Again, No. 616, a boy of 5½ years is only 85 cm tall and has relatively short appendages. His father is 166 cm tall and his mother is of medium height and healthy. This mother's mother was very small, with short hands and feet.

This skipping of generations (of which there are not many cases) would speak against the view that the achondroplastic dwarfism is a simple dominant trait. Also in *most* of the pedigrees the achondroplastic dwarf appears as the only case in the family. Perhaps we may conclude, with PLATE (1913, pp. 349-353), that "in achondroplasy there is a dominant (growth-inhibiting) factor, but that its full expression is often interfered with by other growth-stimulating, or by cancelling or antagonistic, factors."

2. Ateliosis

The longest pedigrees of ateliosis in the direct line extend through 3 generations. There are two of these. No. 731 begins with a man who was only 120 cm tall and was exhibited in shows as a dwarf for 21 years. He had a tall brother. The dwarf married a woman of normal stature and had 2 children. The first, a girl, was small "like a doll" at birth. She grew until she was 13 or 14. She wears gloves of 00 size and shoes of "children's sevens." She is 129.5 cm tall. Her brother was of the usual size at birth but grew slowly; at 38 years he is 132 cm tall. He married a normal-sized woman and had 7 children. Four of

them died when about 3 months old and all are said to have been dwarfs, but this is uncertain. Of the 3 living, 2 are well-developed girls; the one boy is a dwarf aged 10 and is 95 cm tall and a cryptorchid.

No. 695. A Piedmontese Italian man, strong but very small, about 110 to 120 cm tall, had 8 children (2 of whom died young). Of these one is ateliotic. At 33 he is 110 cm tall. He is sexually potent and, by a woman of normal height, has had 2 children and a miscarriage. The elder child is a girl who at birth was very small and at 22 months is behind other children in size although well-proportioned.

No. 747 is a remarkable family but the form of dwarfism is uncertain. We begin with an Italian couple of tall stature who had 5 children of whom all were tall but one. He was a dwarf, 113 cm tall and well-proportioned in all parts of his body. He married a normal woman and they had 9 children of whom 3 died in infancy; 5 of the remaining 6 were dwarfs. 1, ♀, was 113 cm tall and never married. 2, ♂, 135 cm tall, married twice; by his first wife he had 4 children of whom 3 died young and 1 survived to marry; by his second wife he had 4 sons of whom 1 died young, and the other 3, although young, are apparently dwarfs; one at 14 years is 94.5 cm tall; one at 9, 97 cm; one at 7, 91 cm. 3, ♂, only 130 cm tall, married a normal woman and had 5 children; one died young; one is normal; and the other 3 children, though young, are said to be dwarfs. 4, ♀, at 41 years is scarcely 98 cm tall; 5, ♀, is normal; 6, ♀, at 31 is 116 cm tall. The dwarfism in this case is regarded by RISCHBETH and BARRINGTON (1912) (on what ground they do not say) to be "scarcely ateliosis."

An extensive pedigree of ateliotic dwarfism is that of the Prinz and Jenal families of Samnauntal in the Tyrol. These families have repeatedly intermarried and two, at least, out of 3 fraternities containing ateliotics, are from intermarriages of these strains. As PEARSON suggests (Treasury, p. 501, footnote), "The pedigree seems to indicate that true dwarfism might be recessive in the stock ancestral to both Prinz and Jenal families."

I will add some special data on file at the EUGENICS RECORD OFFICE relating to dwarfs:

S. F. ♀, at 40 years is 97 cm tall; all of her children by a man 168 cm tall are apparently of normal size. She has a normal sister who, by a normal man, has two sons. The first at 21 years is 157 cm tall; the second at 15 years is of the size of an 11-year-old child (i. e., about 134 cm, instead of 165 cm). (E. R. O. 024-17.)

Peter W. T. was of normal stature and so were his father and mother.

He had, however, a sister, Cynthia, who was only 104 cm tall. She was of normal intelligence; she never married. Another sister, Lucretia, was 106.7 cm tall; but a third sister and the only brother were of normal height. Peter married a woman of normal stature, possibly related to him. There were 7 children of whom 2 were dwarfs. Of these, one, Emma, was only 78.7 cm tall, weighed 35 pounds and died, unmarried, at 49 years. The other, Addison, was so small that he was sought by P. T. Barnum, the showman. He died at the age of 53 years in an epileptic attack. One of the normal children, Daniel, has a grandson who, at 15 years, is undersized. In view of the fact that this family-complex lived almost under insular conditions the marriages were probably consanguineous in some degree. The inheritance resembles that of a recessive trait. (E. R. O. 15: 343.)

A feeble-minded man, about 168 cm, married a woman who was competent but a small dwarf. Of her 7 sibs one brother and one sister were each about 132 cm in height. The short sister had 3 children of normal size. The father of this fraternity had a height of 132 cm. The children of the first named pair numbered 6: 1, ♀, feebleminded, measured about 150 cm; 2, ♀, was a little over 152 cm; 3, ♀, was 130 cm and had, out of 7 children, one who is only 132 cm high; 4, ♀, about 132 cm tall, had 2 daughters who are cretins, another who is a dwarf and has responded little to thyroid treatment, while 2 are normal. Nos. 5 and 6 were of medium stature. Here one or more shortening factors seem to be "inherited" as a dominant; at least there is an inherited tendency to defect in growth-promoting secretions.

What conclusion can be drawn from the foregoing pedigrees and others that are in the literature? It seems almost necessary to conclude from pedigrees in which the dwarfing tendency has been inherited in a direct line once for 5 generations and several times for 3 generations, that there is present an important *dominant* factor. That only one dominant factor is present in dwarfing cannot, of course, be said. In other cases the result looks as if a recessive factor was at the bottom of ateliosis though one cannot agree with WEINBERG (1912) that we have ever to do with a simple recessive. The offspring of two ateliotics are *usually* of full size at birth and some have developed into full-sized persons. I am inclined to conclude that in both ateliosis and achondroplasia there are multiple dominant (growth-inhibiting) factors—whose actions are also often obscured by opposing epigenetic growth factors, and which are probably of a different sort in ateliosis than in achondroplasia, for achondroplasia affects chiefly or exclusively the appendages.

VI. GIANTS AND HEREDITY IN GIANTISM

CUSHING (1912, pp. 158-170) records a case of a man who at 12 was 183 cm (6 ft) tall and is now, at 48 years, 185 cm (73 in.) tall despite extreme bowing of shoulders. His mother's father was a "giant"; his mother was of average build. He was one of 9 children; one sister of the propositus is large and closely resembles the patient. He married a large woman weighing 200 pounds.

"She had 3 pregnancies; the first, 10 years after marriage, resulted in a child too large to be born. A second child, a girl weighing 17 pounds at birth (1898), survives, and now at 11 years of age is 152 cm (5 ft) in height and weighs 100 pounds. The third, 'an enormous child,' died in its first year from unknown cause."

The case is interpreted as due to extraordinary hypophyseal activity of which there was an exacerbation between the fifteenth and twenty-fifth years.

Again (CUSHING 1912, p. 201), S. G., ♂, 20 years of age, of "high-strung and nervous" parentage, height 179 cm, has dyspituitarism. He has a brother about 193 cm tall and a father 189 cm; his father's father and two uncles are over 183 cm (6 ft).

Of tall families, the Howard family is one of the most interesting: Father, 193 cm (76 inches); mother, 184 cm (72.5 inches). She had 12 brothers and sisters over 183 cm (72 inches) tall. Children: Thomas, 193 cm (76 inches); James, 198 cm (78 in.); John, 214 cm (6 ft. 11½ in.); Elijah, 191 cm (6 ft. 3 in.); Matthew, 198 cm (78 in.); Eli, 199 cm (78.5 in.); Sarah, 188 cm (74 in.); Mary, 188 cm (74 in.); Daniel D., 191 cm (75 in.). In 1856 there were several grandchildren growing over 198 cm (6½ feet) tall. Descendants of the Howard family are now living at Lexington. I measured one who was 188 cm (6 ft. 4 in.) tall and several other men between that height and 183 cm (6 ft.), and two more over 182 cm (5 ft. 11 in.).

Another strikingly tall family is that of the Mac Queens of Queensdale, North Carolina (see MAC ELYEA 1916, from which I quote). The progenitor immigrant was Col. James Mac Queen, born on the Isle of Skye, Scotland, about 1760. "He was a man of superb physique and noble presence." His parents were Archibald Mac Queen and Flora Mac Donald, his wife. He married Ann Mac Rae, "above the medium height," and had 12 children of whom 11 grew to maturity.

1. Archibald "of the finest physical mold"
2. Flora
3. Katherine "far above the size of the average woman"

4. Sarah
5. Edmund   "fully six feet in height"
6. Annabella "of tall, finely proportioned figure"
7. Neill   "tall and slender"
8. John   "tall, of erect and splendid physique, magnificent pro-
              portions"
9. James   "not so tall as his brothers"
10. Maria   "of medium height and stout"
11. Charity   "tall and slender"

The foregoing account of the children of Col. James Mac Queen,
though not quantitative, shows that, of the 9 children described, 7 were
strikingly tall and two were "medium" or "not so tall." But it must
be recalled that the author of the Mac Queen history lived in a com-
munity of strikingly tall persons, so that her idea of "medium" may
have been above the standard adopted by this paper.

The tall Katherine (No. 3) married Col. Donald Mac Queen—"a
man of gigantic physical proportions." They had several children who
grew up:

1. Alexander (6 ft. 3 or 4 inches)
2. Nancy   (6 ft.)
3. James   (6 ft. 2 in.)
4. Flora   "carried the typical stature and size of the family";
              "of imposing presence" (5 ft. 11 in.)
5. Sallie   (5 ft. 10 in.)
6. Margaret   (5 ft. 10 in.)
7. Martin   "tall" (6 ft. 4 in.)
8. Archibald "a man of splendid physique" (6 ft. 2 in.)
9. Effie   "a woman of remarkable height, measuring fully six
              feet" (5 ft. 10 in.)
10. John   "exceedingly tall and ofttimes I have seen him bow
              his head in entering the door of a room" (6 ft. 5 in.)
11. Edmund   (6 ft. 4 in.)
12. Katherine (5 ft. 11 in.)

(The heights in parenthesis were given me by two or three members
of the family.)

Thus all of the children of the tall Katherine and Donald Mac Queen
were tall or very tall. I measured a son of No. 5, Sallie; he (Alexan-
der J.) was 187 cm (73.6 in.) tall; a son of his (Henry) was 185 cm
(72.8 in.) tall and a son of the latter was 189 cm (74.4 in.) tall. In-

deed, all 3 sons of Sallie were over 6 feet, without shoes, and Henry's children (by a tall wife) are all tall or very tall.

John (No. 8), the son of Archibald and Flora, married a woman who "was above the medium height" and "her three sons grew up as giant monuments" (p. 177) being, 6 ft. 1 inch, 6 ft. 4 inches, and 5 ft. 11 inches, respectively. There are plenty of other examples of tall members of this interesting family of north Scotch origin.

Assuming that excessively tall stature is the result of excessive activity of the pituitary gland, then it seems necessary to conclude that peculiarities in the functioning of endocrine glands are influenced by genetic factors—have an inheritable basis.

In all the foregoing families when both parents are tall all of the children are tall; this indicates that the factors for tallness are mostly recessive—probably due to the absence of inhibition to prolonged growth.

E. SUMMARY OF CONCLUSIONS

1. One of the factors that determines variation in stature is probably the variation in age of onset of puberty.

2. Parents of similarly deviant stature have on the average less variable offspring than those of one short and one tall parent.

3. The offspring of two tall parents are less variable in stature than those of two short parents.

4. When both parents are "tall" or "very tall," and of tall stock, practically all the children are tall or very tall.

5. When both parents are "very short" or "short," and of short stock, all children are short or very short.

6. The hypothesis that is tested in this paper is: "short" parents may, and frequently do, carry germ-cells which lack the shortening factors, while in tall parents the gametes are more nearly homogeneous and all lack most of the shortening factors.

7. When the parents are much below the average in stature the offspring regress toward mediocrity; but when the parents are much above the average in stature there is no (or little) filial regression.

8. The least variable offspring are those of two tall parents; the most variable those of parents that are abmodal in opposite directions.

9. The progeny derived from matings of similars are less variable than those derived from matings of dissimilars—a result which indicates that parents of all classes are somewhat heterozygous.

10. Medium stature may appear in the progeny of a tall × short mating, but the majority of persons of medium stature in this country belong to a medium biotype.

11. The truth of the hypothesis formulated in paragraph 6 seems to be established. Shortness is due to certain positive factors that inhibit growth of the various parts.

12. Persons of similar stature tend to marry each other; and extremes are more particular in this respect than those of medium statures.

13. While "growth-as-a-whole" factors are present, yet there is a large degree of independence in the variability of the four segments of stature, considered in this paper. Thus the correlations between suprasternal and substernal segments is .09 ± .04; between knee-to-pubic arch ("thigh") and knee-to-sole ("tibia") .24 ± .04; between standing and sitting height 0.64 ± .03. This independence in variability of the segments of stature makes impossible any simple "Mendelian" laws of inheritance of stature as a whole.

14. Height of upper edge of symphysis pubis varies from 43.6 to 56.5 percent of stature. The ratio of trunk length to stature ranges from 35 to 25.5 percent of stature. The head and neck constitute about 17 percent of the stature.

15. A study of torso length shows that short × medium matings yield offspring that fall, on the average, below mediocrity far more than the offspring of tall × medium surpass mediocrity.

16. The parental category of medium torso seems to be so commonly heterozygous that the progeny of two parents with medium torso are exceptionally variable.

17. When both parents have short fibula about one-fifth of the progeny are at or above the mean stature; when both parents have long fibula none of the offspring are short. In respect to fibula, again, "short" carries the more variable gametes. Here, too, the offspring of two medium parents are exceptionally variable.

18. When both parents have short head and neck about 48 percent of the progeny are medium or above in length of this segment. When both parents have long head and neck about 10 percent of the progeny are medium or below in length of this segment. The offspring of short × short (or very short) matings are more variable than those of long × long (or very long) matings.

19. In general, parental short segments yield a progeny more variable in respect to the given segment than parental long segments; matings long × short yield progeny with a relatively low variability and matings medium × medium progeny with a relatively high variability.

20. In the segments of stature (as contrasted with stature as a whole) we approach a condition of relatively few factors for the character.

21. There are families (potential biotypes) in our population characterized by idiosyncrasies in length of each of the segments of stature.

22. There is evidence that the segments of stature are to a certain extent separately inheritable.

23. One reason why children of two tall parents are sometimes (though rarely) shorter than the parents is because of the chance of the union of the short factors for different segments from opposite sides of the house. In general, if *abCd* be the factors carried by one parent (the capital letter representing a short segment) and *aBcd* be the factors carried by the other parent, then the progeny may be *aBCd* and thus have two shortening factors and be shorter than either parent.

24. The inheritance of *proportional* length of the segments of stature is as evident as the inheritance of absolute differences. Here, too, it is obvious that proportional shortness of any segment depends on more than one shortening factor—just how many cannot be said.

25. The deviations from our standards of the stature segments of infants, negroes, Indians and cretins are similar. These deviations may be called infantile.

26. It is probable that in all forms of dwarfing there are multiple dominant inhibiting factors.

27. In the case of giants, when both parents are tall all of the children are tall; this indicates that the factors for tallness are mostly recessive—probably due to the absence of inhibitions to prolonged growth.

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